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Asian Cropping Systems Research: Micro-Economic Evaluation Procedures

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Asian Cropping Systems Research: Micro-Economic Evaluation Procedures", submitted by Gordon Roy Banta in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Rural Economy, majoring in Agricultural Economics.

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ABSTRACT

This thesis analyzes the micro-economics component of cropping systems research in Southeast Asia. More specifically it examines the program of the Asian Cropping Systems Network and the role of the International Rice Research Institute. The objectives of the study were to describe the multidisciplinary cropping systems research approach, with emphasis on the economic component; the role of the agricultural economist; and to develope informal economic analysis procedures which could be used by team economists on the respective research sites.

The cropping systems program involves a multidisciplinary team conducting interdisciplinary research on a specific problem set. The research sites are the farmers' fields with the farmer as a partner in the research. The major task of the agricultural economist on the team is to assist in the evaluation of the new technology arising out of the cropping systems research. A survey of twenty-two sites revealed that the economic analysis procedure being used was providing results which were too late to be of use in designing next year's research program. This ineffectiveness was found to lead to frustration of the agricultural economist and other team members.

To speed up the economic analysis it was recommended that a complete set of records be obtained from a few modal case study farms. This would replace the traditional large sample survey. The results

would provide less but equally relevant data. It also ensures that team members will work closely with farmers in testing the new technology.

A set of informal procedures was developed to utilize the case study approach in evaluating profitability of the new technology. These informal procedures involved partial budgeting, graphing for resource constraints and program planning. They were tested against the more formal procedures for accuracy of conclusions as well as time and other resource requirements. The informal procedures were found to be less precise but equally accurate in predicting the acceptability of new technology arising out of cropping systems research in the farm environment. Furthermore the informal procedures and results were found to be more easily understood by other team members.

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TABLE OF CONTENTS

CHAPTER PAGE

I. INTRODUCTION AND OVERVIEW 1

Asian Population Trends 1

The Asian Land Base 2

Food Production in Asia 5

The Asian Farmer 8

Agricultural Research 11

REFERENCES 13

II. THE PROBLEM AND OBJECTIVE OF THE STUDY 16

The Over-all Problem 16

The Specific Problem 17

The Objectives 19

III. IRRI's CROPPING SYSTEMS PROGRAM 21

Cropping Systems in Asia 21

Evolution of Cropping Systems Research 23

Systems Approach to Research 27

The Current Cropping Systems Program at IRRI 31

Asian Cropping Systems Network 35

Impact of the IRRI Cropping Systems Program 38

Future Directions of IRRI's Cropping Systems Program . 42

REFERENCES 45

CHAPTER PAGE

IV. METHODOLOGY AND ANALYTICAL PROCEDURES 48

The Field of Farm Management 48

The Role of Management Science in Farm Management 49

The Management Process 50

Objectives and Goals 51

Decision-Making Process 51

The Role of Production Economics 52

The Basic Economic Decision in Production 53

The "How much to produce" Decision 54

The "How to produce" Decision 57

The "What to produce" Decision 59

The Principle of Opportunity Cost 64

Dynamic Versus Static Analysis 64

The Present Status of Farm Management Economic Research 66

The Role of the Economist in Cropping Systems Research 69

Brief Review of Cropping Systems Research at IRRI... 69

Site Study of Economists' Activities 71

Economic Analytical Procedures 75

Formal Procedures 76

Production Functions 76

Linear Programming 77

Informal Procedures 78

CHAPTER PAGE
IV. Partial Budgets 80
A hypothetical example of partial budgeting 81
Graphing 84
A hypothetical example of graphing 85
Program Planning 87
A hypothetical example of program planning 92
REFERENCES 96
V. SITE DESCRIPTION AND DATA COLLECTION 99
The Sites 99
Batangas 99
Land 101
Population 101
Iloilo 105
Land 105
Population 106
Pangasinan 109
Land 110
Population 111
Data Collection 114
Batangas 114
Baseline Survey 114
Record-Keeping 115
Iloilo 116
Baseline Survey 116
Record-Keeping 117
Pangasinan 118

CHAPTER PAGE

V. Baseline Survey 118
Record-Keeping 120
REFERENCES 122
VI. ANALYSIS AND RESULTS 125
The Cale Site 125
Descriptive Analysis of Farming System 125
Cost and Returns from Farm Data 134
All Farms 134
Five Farms 141
Transferring Income Variability 148
Factors of Production 152
Variability in Factors of Production 153
Independence 158
Homogeneity 158
The Case Study Approach 160
Pretesting Informal Procedures 161
Budgets 162
Graphs 164
Program Planning 166
Comparison of LP and Informal Procedure Solutions 170
Detailed Analysis of One Farmer 173
The Iloilo Site 177
The Pangasinan Site 181
REFERENCES 184

CHAPTER PAGE

VII. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS 185

Summary 185

Conclusions 186

Recommendations 191

BIBLIOGRAPHY 192

APPENDICES

APPENDIX 1 SURVEY OF CROPPING SYSTEMS ECONOMIC METHODOLOGY 200

APPENDIX 2 COMMON ENGLISH AND SCIENTIFIC NAMES OF ANNUAL CROPS GROWN IN CALE, BATANGAS 203

APPENDIX 3 INFORMAL PROCEDURE ANALYSIS OF EIGHT CASE STUDY FARMERS 205

LIST OF TABLES

TABLE PAGE

I-1 Population and Cereal Production Growth Rates 3

III-1 Description of Cropping Systems Network Test Sites, 1977 41

IV-1 Summary of Economic Data Collection and Analysis Activities at 22 Asian Cropping Systems Sites 72

IV-2 Gross Returns and Variable Costs: An Example 82

IV-3 Example of Partial Budgets 83

IV-4 Program Planning Example 93

V-1 Population of Tanauan by Age and Sex 102

V-2 Land Tenure in Batangas 103

V-3 Relationship of Farm Classification and Land Tenure in Batangas 104

V-4 Fragmentation and Areas of Farms in Tanauan 105

V-5 Population of Oton and Tigbauan 107

V-6 Population and Households of the Five Selected Villages in Iloilo, 1975 108

V-7 Land Tenure in Iloilo 108

V-8 Relationship of Farm Classification and Land Tenure in Iloilo in 1971 109

V-9 Population of Manaoag by Age and Sex in 1975 111

V-10 Population and Households of the Five Selected Villages in Pangasinan, 1975 112

TABLE PAGE

V-11 Land Tenure in Pangasinan 113

V-12 Relationship of Farm Classification and Land Tenure in Pangasinan, 1971 114

VI-1 Area Planted to Crops on Thirty-Six Farms in Cale, 1973-77 126

VI-2 Costs and Returns for Rice in Cale, 1973-1977 135

VI-3 Costs and Returns for Maize in Cale, 1973-77 137

VI-4 Costs and Returns for Vegetables in Cale, 1973-77 140

VI-5 Planted Area and Gross Returns from Garlic in Cale Based on Thirty-Two Farmers 141

VI-6 Input by Source and Production for Farmer 18, Cale 1973-77 143

VI-7 Input by Source and Production for Farmer 20, Cale 1973-77 144

VI-8 Input by Source and Production for Farmer 24, Cale 1973-77 145

VI-9 Input by Source and Production for Farmer 32, Cale 1973-77 146

VI-10 Input by Source and Production for Farmer 50, Cale 1973-77 147

VI-11 Crop Production Distribution to Farm Family, Landlord and Share Worker for Five Families Over Four Years, Cale, 1973-77 149

VI-12 Actual Input and Product of Five Farms Over Four Years in Cale 150

TABLE PAGE

VI-13 Frequency Distribution Characteristics of Inputs and Input Ratios for Crop Production in Cale, 1973-77 154

VI-14 Frequency Distribution Characteristics of Output for Crop Production in Cale, 1973-77 157

VI-15 Correlation Coefficients Between Factors Affecting Crop Production in Cale, 1973-77 159

VI-16 Comparison of Experimental Data for Sorghum and Farmers' Data for Maize in Cale, 1975-76 163

VI-17 Partial Budget to Compare Maize with Sorghum based on Fifty-Eight Parcels of Maize and Ten of Sorghum, Cale, 1975-76 164

VI-18 Program Planning Comparing Mean Data for Maize and Sorghum Data, Cale, 1975-76 167

VI-19 Comparison of Five Farmers' Actual Maize Data with Sorghum Experimental Data for Same Area, Cale, 1975-76 ... 168

VI-20 Program Planning for Farmer 18 Comparing Sorghum with Current Maize Production, 1975-76 169

VI-21 Program Planning for Farmer 24 Comparing Sorghum with Current Maize Production, Cale, 1975-76 171

VI-22 Budget Comparison of Farmers and New Technology Farmer 1, Iloilo 174

VI-23 Initial Matrix and Solution for First Crop Period Farmer 1, Iloilo 175

VI-24 Initial Matrix and Solution for Second Crop Period Farmer 1, Iloilo 178

TABLE PAGE

VI-25 Informal Cropping Pattern Solution Farmer 1, Iloilo 179

VI-26 Comparison of Informal Procedure and LP Solutions for Iloilo 180

VI-27 Comparison of Informal Procedure and LP Solutions for Pangasinan 182

APPENDIX 3

3-1 Budget Comparison of Farmers and New Technology Farmer 2, Iloilo 206

3-2 Initial Matrix and Solution for First Crop Period Farmer 2, Iloilo 207

3-3 Initial Matrix and Solution for Second Crop Period Farmer 2, Iloilo 208

3-4 Informal Cropping Pattern Solution Farmer 2, Iloilo 209

3-5 Budget Comparison of Farmers and New Technology Farmer 3, Iloilo 210

3-6 Initial Matrix and Solution for First Crop Period Farmer 3, Iloilo 211

3-7 Initial Matrix and Solution for Second Crop Period Farmer 3, Iloilo 212

3-8 Informal Cropping Pattern Solution Farmer 3, Iloilo 213

3-9 Budget Comparison of Farmers and New Technology Farmer 4, Iloilo 214

3-10 Initial Matrix and Solution for First Crop Period Farmer 4, Iloilo 215

TABLE PAGE

3-11 Initial Matrix and Solution for Second Crop Period Farmer 4, Iloilo 216

3-12 Informal Cropping Pattern Solution Farmer 4, Iloilo 217

3-13 Budget Comparison of Farmers and New Technology Farmer 5, Iloilo 218

3-14 Initial Matrix and Solution for First Crop Period Farmer 5, Iloilo 219

3-15 Initial Matrix and Solution for Second Crop Period Farmer 5, Iloilo 220

3-16 Informal Cropping Pattern Folution Farmer 5, Iloilo 221

3-17 Budget Comparison of Farmers and New Technology Farmer 1, Pangasinan 222

3-18 Initial Matrix and Solution for Firstrop Period Farmer 1, Pangasinan 224

3-19 Initial Matrix and Solution for Second Crop Period Farmer 1, Pangasinan 225

3-20 Informal Cropping Pattern Solution Farmer 1, Pangasinan .. 226

3-21 Buget Comparison of Farmers and New Technology Farmer 2, Pangasinan 227

3-22 Initial Matrix and Solution for First Crop Period Farmer 2, Pangasinan 229

3-23 Initial Matrix and Solution for Second Crop Period Farmer 2, Pangasinan 230

3-24 Informal Cropping Pattern Solution Farmer 2, Pangasinan .. 231

3-25 Budget Comparison of Farmers and New Technology Farmer 3, Pangasinan 232

TABLE PAGE

3-26 Initial Matrix and Solution for First Crop Period Farmer 3, Pangasinan 233

3-27 Initial Matrix and Solution for Second Crop Period Farmer 3, Pangasinan 234

3-28 Informal Cropping Pattern Solution Farmer 3, Pangasinan .. 235

3-29 Budget Comparison of Farmers and New Technology Farmer 5, Pangasinan 236

3-30 Initial Matrix and Solution for First Crop Period Farmer 5, Pangasinan 237

3-31 Initial Matrix and Solution for Second Crop Period Farmer 5, Pangasinan 238

3-32 Informal Cropping Pattern Solution Farmer 5, Pangasinan .. 239

LIST OF FIGURES

FIGURE PAGE

III-1 Components of the Cropping Systems Research Methodology .. 32

IV-1 Basic Production Decisions 54

IV-2 Production Function with Average and Marginal Products ... 56

IV-3 Input-Output Relationship with Price Line 58

IV-4 Input-Input Relationship with Price Line 60

IV-5 Isoresource Line 62

IV-6 Output-Output Relationship with Price Line 63

IV-7 Labour Hours for Twenty Hectares Example 86

IV-8 Animal Hours for Twenty Hectares Example 88

V-1 Cropping System Research Sites in the Philippines 100

VI-1 Crops on Parcel 25-1 in Cale, Tanauan, Batangas, 1973-74 . 127

VI-2 Crops on Parcel 25-1 in Cale, Tanauan, Batangas, 1974-75 . 128

VI-3 Crops on Parcel 25-1 in Cale, Tanauan, Batangas, 1975-76 . 129

VI-4 Crops on Parcel 25-1 in Cale, Tanauan, Batangas, 1976-77 . 130

VI-5 Farming System (Farmer No. 20) 132

VI-6 Cropping System (Farmer No. 20) 133

VI-7 Comparison of Maize and Sorghum Labour Use at Planting for Five Farmers in Bo, Cale, Tanauan, Batangas 165

CHAPTER I

INTRODUCTION AND OVERVIEW

Asian Population Trends

The large-scale introduction of medical technology into Asia since World War II has resulted in substantial population increases. Average annual population growth rate has risen from 1.6 percent in the 1950's to 2.6 percent in the 1970's.[1] This dramatic increase in growth rate is due mainly to a decline in mortality rates. The annual birth rate has remained relatively constant at around 40 per 1,000, while the mortality rate has dropped from approximately 25 per 1,000 in the 1930's to half of this amount in the 1970's.[2] Prior to the introduction of health programs in Asia, mortality rates were high due to a wide variety of diseases. Since medicine applies universally to the human organism, scientific and technological transfers from one country to another can be made with relative ease. For instance, smallpox vaccine developed in Europe has now eliminated this once dreaded disease on a world-wide basis.

Technology has also reduced death in fields other than medicine. For example, in 1946-47 the public health services in Sri Lanka (then Ceylon) instituted a household spraying program with DDT. The death rate was cut by 40 percent within a single year.[3] The experience in Sri Lanka was one of the first examples of what could be expected in

Asia from large-scale public health programs.

Unfortunately, the changes occurring in mortality and population rates are not recorded accurately. In 1956, the United Nations estimated that only 48 percent of the births and 33 percent of the deaths in the world were recorded. In parts of Asia this estimate dropped as low as 8 percent.[4] For more than thirty years demographers have been making population projections for Asia based on this incomplete data. As might be expected, their projections have not been very accurate. In 1958, the United Nations with its worldwide data-gathering network, published a set of population projections for the year 2000.[5] In 1961, their data showed that world population had already reached the growth rate estimate for the year 2000, with Asia exceeding this level.[6]

Although the exact numbers are not known, it is clear that the population of Asia has been increasing faster than at any time in its history. Based on the latest estimates, over-all annual population growth rate for Asia exceeds 2.5 percent. Even more disturbing is the observation that in half of the Asian countries the annual growth rate rose each year between 1963 and 1976. (Table I-1)

The Asian Land Base

With constant technology, population increases require an expanding land base to maintain food supplies. How much arable land can be found in Asia? Two major studies on this question arrived at similar answers: 6.1, and 6.3 million hectares.[7] [8] However, their assumptions about the real and potential productivity of the land differed. The 1967 report of the President's Science Advisory Committee stated:

> In Asia if we subtract the potentially arable land area in which water is so short that one 4-month growing season is impossible, there is essentially no excess of potentially arable land over that actually cultivated.[9]

TABLE I-1

POPULATION AND CEREAL PRODUCTION GROWTH RATES

Country	Period[a]	Population (Percent)	Cereals per capita (Percent)
Bangladesh	1	2.9	-0.3
	2	1.7	1.4
Burma	1	2.3	-1.0
	2	2.4	0.4
India	1	2.4	1.9
	2	2.5	-0.4
Indonesia	1	2.6	3.3
	2	2.6	0.4
Kampuchea	1	2.8	2.0
	2	2.8	-17.7
Laos	1	2.2	3.4
	2	2.2	-1.6
Malaysia (Peninsular)	1	2.8	3.4
	2	2.8	-0.1
Sabah	1	3.6	-0.3
	2	3.8	1.3
Sarawak	1	3.2	2.2
	2.	3.7	-2.0
Nepal	1	2.1	-0.7
	2	2.3	-0.5
Pakistan	1	2.8	6.3
	2	3.2	-0.1
Philippines	1	3.2	1.8
	2	3.4	1.4
Sri Lanka	1	2.4	5.3
	2	2.2	-5.0
Thailand	1	3.1	-0.2
	2	3.3	-0.4
Vietnam	1	2.5	-2.5
	2	2.1	0.9
China	1	1.7	1.4
	2	1.7	0.9

SOURCE: Fourth World Food Survey, (Rome, Italy: Food and Agriculture Organization of the United Nations, 1977), pp. 69-76.

[a] 1 is period 1961/65-70; 2 is period 1970-76.

However, in spite of their assumption, some of this land is cultivated. Consequently the group finally concluded that there was an estimated additional 108 million hectares of uncultivated land that had some crop production potential.[10] It is likely that most of this area is either so unproductive or so remote from markets that, with current prices, cultivation is not justified.

Ten years later, an even more pessimistic report, which assumed labour-oriented agriculture would continue in Asia, estimated there were 610 million hectares suited to crop production in Asia. However, the study found 689 million hectares presently cultivated. The report also estimated that the sustainable population was 947 million, assuming a labour-oriented agricultural technology, while the population was 2,400 million indicating a 153 percent overpopulation.[11]

In 1972, Meadows et al estimated there were 3,200 million potentially arable hectares in the world. This was in agreement with the two aforementioned studies.[12] However, he qualified this estimate by pointing out that the potentially arable area consists mainly of arable land being used for non-agricultural purposes. Buringh confirms this and estimates the loss of arable land worldwide at 5.3 million hectares per year.[13] On that premise, since Asia contains one-third of the presently cultivated land, it seems likely they are losing at least 1.5 million hectares a year. Meadows et al also noted that in some areas, including parts of Asia, a shortage of water rather than land would be the first factor to limit food production.[14]

According to the FAO Production Yearbook (1977) an additional 7 million hectares was brought under cultivation in the Far East between 1961/65 and 1970, while in the period 1970-76, over 9 million hectares were added to the area farmed. Yet, the land base per capita has fallen from 0.27 hectares in 1965, to 0.22 hectares in 1976. Although nearly 14 million additional hectares were estimated to be under cultivation, the population had grown by 270 million.[15] Thus, the additional land put under cultivation did not keep pace with population increases.

While projections for the future can only show general trends, there is little indication that the population-land ratio will stabilize. Projections of the 1965-76 trends for example, indicate that by the year 2000, there will be only 0.04 hectares of arable land per capita in the Far East, using linear projections.

Food Production in Asia

Cereals are the major food in Asia making up 80 percent of the food consumed, with rice accounting for 59 percent.[16] Thus, any discussion of food in Asia must be primarily concerned with plantings and yields of rice. However, before taking a detailed look at the rice situation, a general food overview may be useful. Per capita food supply has remained relatively unchanged over the past several decades. For example, in 1961-63, per capita food supply in the Far East from all sources was 2,012 calories per day. In 1969-71, the supply was 2,068 and 1973-74, 2,039 calories.[17] During this same period, the protein supply also remained constant at forty-nine grams per capita per day.[18]

The gross cereal deficit for Asia went from an estimated 11.5 million tonnes in 1969-71 to 18.3 million tonnes in 1974-75, and is expected to reach 46.3 million tonnes in 1985-86.[19] However, the problem is centred in a few countries. Bangladesh, Burma, India, Indonesia, Nepal, Philippines and Sri Lanka account for almost 75 percent of the people in low income, food deficient, developing market economies that form the core of the world's food problem. In 1975, the gross deficit in the production of the major staples by this group was nearly six million tonnes. The projected deficit by 1990 may be six times larger, depending on the growth of per capita income and population growth.[20]

In Table I-1, of the sixteen Asian countries shown, ten have had a decrease in cereal production growth rates per capita comparing 1961-65-70 and 1970-76. Of these, eight are actually falling behind the population growth rate in the most recent period. This deficit was met partly by imports and partly in increased hunger. In 1975, the average food available per capita had 7 percent fewer calories than FAO/WHO energy standards.[21] For Asia to meet its food needs by 1985, production within Asia must increase from 2.4 percent annually to 4.2 percent or more if per capita income or population increase faster than projected.[22] So far, growth rate of more than 4 percent in food production has been achieved by only a few countries, and for a short period of time.

Rice production appears to be an important factor in ameleorization of Asia's food problem. Using the nine major rice growing countries[23] of South and Southeast Asia, the International Rice Research Institute (IRRI) has studied rice production and the effects of factors such as irrigation, modern varieties, fertilizer and their interaction. With an average of 10 percent increase in fertilizer use, it was estimated there could be an annual raise in rice production of 2.3 percent by 1985, if the irrigated area were to grow at 3 percent per annum. If the irrigated area grew at 2 percent per annum, rice production was estimated to increase 1.8 percent annually by 1985. A 3 percent per annum increase would involve an over-all annual investment cost of about 2 billion dollars.[24] However, even a 2.3 percent increase in rice production will not meet the needs of the people in these countries. In a review of the implications of the study the IRRI economists state the alternatives very clearly.

> The model's projections imply that in the absence of technology change, it will be impossible for production to grow fast enough to meet demand even with the level of annual investment twice as high as that of the past decade . . . The results suggest that continued reliance on fertilizer and irrigation as major sources of output growth is likely to be extremely costly unless steps can be taken to increase the productivity of these inputs. This can be accomplished only through further emphasis on research and extension that will (1) close the gap between potential and actual yields with present technology, and (2) raise the potential by developing and disseminating better technology.[25]

Considering population growth, available arable land, and crop production increases it is clear there is a food problem in Asia, which will get worse. A variety of recommendations and suggestions have been made on ways to solve or at least stave off the problem until population growth can be stabilized. Hopper suggests a massive irrigation program in the Gangetic Plain which could add 70 or 80 percent to present world grain output on a stable basis, but which would require 60 billion dollars.[26] Considering India's gross national product is 80 billion dollars there seems little chance of such a program. The limited probability of any such scheme being started with foreign aid is made clear when it is considered that the Indicative World Plan for Agriculture prepared in the late 1960's required 112.5 billion dollars over a twenty-three year period. The plan called for 8.5 billion dollars in 1962 rising to 26 billion dollars in 1985. In 1975 the commitments to the plan were 3.5 billion, in constant 1972 prices, with 40 percent non-concessional assistance.[27]

It is evident that the resources needed for large over-all programs are not going to be available in the near future unless there is a radical change in the actions of the materially rich countries. The countries of Asia need to make use of the resources they have combining them with whatever technology is available to increase food production as quickly as possible. A relatively new research program being developed in Asia may be able to assist in meeting the food shortage. This program is called cropping systems research.

The food production in Asia will ultimately be decided by the 276 million people economically active in agriculture.[28] For discussion purposes they will be called the farmers although it is realized many are wives, children, and hired workers. The actual number of farmers is not known and it is not important for the discussion. Since these farmers are the ultimate users of the agricultural research in Asia it is useful to describe some of their socioeconomic characteristics.

The Asian Farmer

Throughout this, and numerous other studies, general reference is made to the farmer as though Asian farmers were a relatively homogeneous group. This is not the case. First, there is variation in their farm size: 25 percent are less than 0.5 hectares in size, while 20 percent range from 0.5 to 1 hectare. Twenty-two percent range from one to two hectares while 33 percent are over two hectares.[29] Second, there is variation in production potential of the land ranging from 800 to 1,750 kg of grain per hectare.[30] Third, some have irrigation or partial irrigation, which totally changes their farming operation. Fourth, they face very different cost-price ratios. The fertilizer/rice price ratio is approximately seven to one in Thailand and three to one in other parts of Asia.[31] Fifth, they live in diverse cultures, and so have different needs.

Generally, the farmers' resource bases differ, but are usually very limited. They experience prices varying widely not only from one location to another, but from one year to the next. All have different derived needs, but most of these needs can be met with a common unit, money.

In spite of this wide diversity, a typical example may help to describe the situation of the Asian farmer. The typical farmer has a land area that in a good year will produce three tonnes of rice and in a poor year one tonne. This land also produces 150 dollars worth of other crops in a good year and fifty dollars in a poor year. He owns ten chickens and a half share in a water buffalo. In the dry season he gets a little off-farm work that earns him an extra thirty dollars. He, his wife and four children, live in a house constructed of local materials. The total value of items in the house including a small transistor radio is fifty dollars. His farm equipment consists of a wooden plough with a steel point, a wooden harrow and plank, a hoe, some carrying baskets, and a few sacks. He transplants most of his rice but broadcasts some. After the rice crop is growing he buys whatever fertilizer the shopkeeper is selling, if he has money or can borrow from the shopkeeper. He exchanges labour with the neighbours at transplanting and harvesting times. He is lucky; he is the only son who lived so he inherited his father's land. He has two sons, so he hopes the youngest does well in school and will be able to get a government job.

The farmer is using his limited resources effectively. His production in a normal year is close to his consumption needs. He has a cropping system which provides minimum variability over time even though it means lower production than possible in good years. The farmer is not particularly responsive to price changes for the crops he plans to eat. Generally, he does not like to grow only cash crops and buy his rice. He knows that when there is a bad year with a rice shortage the relative price of rice and a cash crop can change by a ratio of as much as ten to one. The farmer is, however, price-responsive regarding the cash crops he grows. He is quick to adopt any technology which will stablize his food supply at a high level or which will increase his cash crop income, provided it does not decrease his food supply and he can get the resources needed.

He is a rational decision-maker trying to meet his needs. Taiwan is often considered a leader in Asia in the development of its agriculture and yet a survey of Taiwan farmers came to the following conclusions:

> In sum, the objective of farm operation in the survey area is still self-sufficiency. As crop production is mainly for home consumption, and livestock for compost producing, farmers' production planning is less influenced by the economic factors.[32]

The concepts and attitude expressed by Allaby are in such complete opposition to this study they are worth noting.

> Farming though, is such an old business, and farmers have acquired such a range of skills, that always there are dangers of rediscovering the wheel, of devising a cunning new technique that in some odd corner peasants have been practicing for centuries . . . I claim no originality for the discovery that if there is a world food problem it is not really susceptible to agricultural solutions.[33]

Farmers through centuries of trial and error have learned a lot and it should be one of the functions of agricultural scientists to learn, understand and extend these ideas to others who have not discovered them. Another function of agricultural scientists is to develop new technology which makes more efficient use of resources, indicating to policymakers where a reallocation of resources will lead to greater productivity.

Agricultural Research

A number of organisations are trying to assist the Asian farmers through agricultural research. In each country there is a department of agriculture that has the specific objective of increasing food production. Most of the research supported by the departments of agriculture is product or discipline oriented. Although their major function is training, most universities have some research programs. These usually tend to be narrower in scope than those of the departments of agriculture. Outside agencies such as the Asian Development Bank and the Canadian International Development Agency, sponsor projects which may have a small research component. Finally, there are a number of agricultural research institutions. The International Rice Research Institute (IRRI) is one of these. IRRI's role is to increase rice yields. A few years ago, IRRI realised that rice production could not be looked at in isolation, so a cropping systems program was started. This program aims to increase the productivity of rice-based cropping systems.

It has become clear that a systems approach was needed to study Asian cropping systems over a range of environments. Officials in the departments of agriculture of the various Asian countries have expressed increasing interest in a systems approach to agricultural research. Thus, it was decided to start an Asian Cropping Systems Network. This network is a voluntary grouping of selected officials from the various departments of agriculture. The over-all objective of the network is to promote the systems approach, to exchange ideas on methodology, and to share the results of this type of research. The concept of systems research is relatively new and there are still many questions about efficient methodology and procedures. This study is concerned with finding more efficient procedures for the microeconomic evaluation of cropping systems research.

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CHAPTER II

THE PROBLEM AND OBJECTIVE OF THE STUDY

The Over-all Problem

Since the population of Asia is increasing at over 2 percent a year, and the physical resource base to produce food is nearly fully utilized, new technology to produce more food must be found and used if famine is to be held off. New food production technology is being developed in Western countries. Nearly all of this new technology is based on the assumption that the farmer has access to a relatively large resource base and an infrastructure that can supply strong technological support services. In addition, much of the Western-developed technology involves increasing specialization and assumes labour is a high cost factor of production.

Given the agricultural situation in Asia, it is not difficult to understand why the direct transfer of Western technology has met with such limited success. The problem is not only that the direct transfer of technology has not worked, but also that the Western approach that produced this technology has not worked well in Asia. The discipline or commodity-specific research approach which was transferred to Asia to solve the farmers' problems has only worked in environments that are suited to specialization. In most of Asia, the trend is in the opposite direction. Due to population pressure on a limited land base, farms are getting smaller and there is more diversification as farmers try to fully utilize their limited resources. The over-all need is to develop and implement research procedures that will produce new technology that is suited to small, diversified farms.

In order to develop technology that will be used it is essential to determine the current constraints in the farming system, and identify potential areas for improvement. This means that the current system must be understood. This understanding must include not only the cropping system but also its major interactions with other activities on the farm and should not simply be a list of input and output coefficients. Up to the present, a major portion of agricultural research in Asia has not considered the farm system into which the new technology must fit. In fact, little work has been done on developing an understanding of the farm as a production and consumption unit.

No one discipline can supply this. Interdisciplinary study is needed to effectively understand and describe the current Asian farms. It was to meet this need and to supply a basis for developing new technology that a cropping systems program was started at IRRI in the Philippines and tied into a network of similar programs in most Asian countries. This program is discussed in Chapter III. It is based on a multidisciplinary team conducting interdisciplinary research on a specific problem. The over-all objective of the team is to enable the farmer in a given environment, to produce more food.

The Specific Problem

The cropping systems teams have not been as effective as had been hoped. When any group decides to work together it is assumed that the product of its efforts will be greater than if each group member had worked alone. But, inherent in this assumption is another assumption, that each member of the group or team can and will contribute effectively to the team.

Throughout the cropping systems research programs in Asia there have been repeated discussions about the role of economics and its contribution. Generally speaking, it is agreed that the economic component requires improvement. In these discussions several specific problems usually are identified. First, the economic results are of little assistance in the decision-making process. Mostly this has been due to the late arrival of the results. Often the economic analysis of the research arrives after the next experiment has begun.

The second problem often mentioned is the economists' growing frustration about their work. The data is generated faster than they can handle it. At many sites, detailed record keeping takes so much time there is little time left to work on analysis. The frustration is aggravated by the fact that most of the other team members can finish their analyses in several weeks. The agronomists can then discuss the results with the farmers while the factors regarding the research are still fresh in the farmers' mind but the economist can contribute little due to lack of timely analysis.

Reasons for the economists' ineffectiveness need to be examined. Is the division of labour between data collection and analysis the most productive? Are the analytical methods and procedures appropriate for the job to be done, and do the economists know how to use them? These types of problems will be explored in this thesis.

The Objectives

There are four objectives to this study.

The first objective is to give the reader an understanding of IRRI's cropping systems research with particular emphasis on the Asian Cropping Systems Network. The description of the research approach and a relatively complex cropping system should supply a framework from which the need for a multidisciplinary team to conduct interdisciplinary research can be understood. The description should provide a basis from which specific problems, particularly in the economic aspects of the research, can be analyzed.

The second objective is to study the economists and their work, to find ways to make them more productive. This study would answer the following questions: who are the economists, where and how are they working, and what are they doing? Any suggestions for improvement in the economist's functions must meet the following criteria. First, the procedure must be mathematically and statistically simple. Second, the analysis for a typical site should be able to be completed in about one month. Third, the results of the analysis should be in a form that any member of the cropping systems research team can readily understand.

The third objective is to review the validity and complexity of the econometric procedures that economists in the cropping systems program are now using. Most economists are using traditional econometric procedures, assuming that the basic assumptions of the procedures have been met and that they are the most efficient way to analyze cropping systems.

The fourth objective is to develop a set of informal procedures that an economist can use to analyze the testing phase of cropping systems research. The procedures should have data requirements that allow the economist sufficent time for analysis and to conduct research on other specific problems. The results of the informal procedure should lead to the same conclusions as a formal procedure such as linear programming. Each step in the informal procedure should lead to a decision answering the basic question: is the alternative technology worthwhile? The informal procedure should be sensitive and complete enough so that relationships which are inconsistent with theory can be found and analyzed within the framework of the procedure.

CHAPTER III

IRRI's CROPPING SYSTEMS PROGRAM

Cropping Systems in Asia

Rice is the major crop in Asian cropping systems. It is the basic food of over 500 million people and grown on over 80 million hectares in the Far East.[1] Due to its wide genetic variability rice cultivation ranges from high up the Himalayan slopes in Nepal on fields with a 20 percent slope, to the flat flood plains of Bangladesh under two or three metres of water. Rice is grown from the USSR/China border at 53^{o}N latitude[2] to 35^{o}S in Southeast Australia.[3]

Up to the mid-1960's rice production technology had been virtually unchanged in South and Southeast Asia for centuries. A few nitrogen-responsive varieties from Japan and Formosa had been tried but were not suited to the environment. Irrigation was the only variable in technology and this usually was a major undertaking that was decided by the government of a country. Rice yields were stable except for variations due to weather. In the Philippines rice yields ranged from 1.0 to 1.3 tonnes per hectare from 1930 to 1965, with the highest yield in 1930.[4]

There is a major difference in rice cropping patterns depending on the water regime in which it grows. In the mid-1970's, Barker and Herdt divided the regimes by area: irrigated double-cropped 19 percent;

irrigated single-cropped 13 percent; shallow rainfed 34 percent; mid-deep water 15 percent; upland 10 percent; and deepwater 8 percent.[5] They estimated that the 32 percent area which is irrigated, accounts for 50 percent of the rice production.[6] In another study, Moorman and van Breemen considered the soil and water environment for rice in Asia and came to the conclusion that "Agricultural systems based on rice as the food staple are thus clearly lowland systems".[7] The lowland systems--all the rice area except upland and some deepwater--have one characteristic in common: the land is puddled. When sufficient water is available on the field, the soil is worked until all the soil structure is gone. Then the rice seedlings are transplanted.

Puddling has several advantages. It is an effective weed control practice. By forming an anaerobic solution many nutrients are more readily available to the rice plant. It reduces water losses through percolation and evaporation.[8] Although of benefit to rice cultivation, puddling makes the growing of upland crops in the same field extremely difficult in the short growing season before or after rice.

In the mid-1960's, a new era in rice production in South and Southeast Asia started. A cross between an Indica and Japonica type was made at IRRI in the Philippines. Named IR8, it could yield over ten tonnes/hectare in 122 days if given sufficient fertilizer and an adequate environment. Although it had many weaknesses, the cultivar and its successors had several characteristics which were to have a profound effect on cropping systems in Asia. First, it was non-photoperiod sensitive, so it could be planted any time and harvested 122 days later. Second, because it only took 122 days to mature, areas with five or six months' rainfall had sufficient time to grow another crop. Third, it had a high response to fertilizer so the farmer who wanted to take advantage of this potential would need to market farm products to pay for the fertilizer. The subsistence farmer would be starting to enter the market economy on a larger scale.

The impetus for new technology and a vast potential for change was in the seed of the new rice varieties. The problem was that no one knew where the seed, with all its changes, would flourish and where it would not. The Asian rice farmer and his cropping system was still a vast unknown. Many aspects had been looked at, but there was no synthesis of the information.

Evolution of Cropping Systems Research

One of the first people to see the potential impact of the short non-photoperiod sensitive rice, and to do something about it, was Dr. R. Bradfield. In 1964, he suggested taking advantage of the solar radiation and soil moisture by multiple cropping.[9] He suggested more crops per year by relay interplanting, minimum tillage, harvesting at physiological maturity, and intercropping. His approach could be summed up in the phrase: "An absorbing surface of several layers of green leaves of growing plants must be interposed between the sun and the soil."[10] By 1970, he was working full-time on multiple cropping, as well as publicizing his views on Asian agriculture. He observed that there were two types of agricultural areas in the world, those where science had been applied and those where it had not. Yields in South and Southeast Asia were low because of a failure to invest in research and technology. He suggested that there were three methods to increase food production: increase the area under cultivation, increase yields, and grow more crops per year. He urged that more emphasis be placed on the third method. He noted that the tropics had a much higher plant production potential than the temperate zones, citing as an example that a tropical rain forest produces four times as much dry matter per year as a temperate deciduous forest.[11] Dr. Bradfield's work done in the IRRI research fields, involved techniques to grow more crops per year on a given piece of land. He visited Taiwan several times and was impressed with the productivity of its cropping systems, incorporating many of the techniques observed there into his work. One of the more productive patterns he developed, involved the production of five crops in one year.

In 1972, Multiple Cropping became known as Cropping Systems, and part of the research program was moved on to farmers' fields. The first site chosen was Cale in Batangas, about 30 km from IRRI. Regardless of what was thought and said later, the selection of the site was for one main reason:

> The area is not typical of the rest of the Philippines. It has very sophisticated systems. If we can develop the ability (methodology) to analyze the systems there, we should be able to handle any others.[12]

The farms in Cale were very productive and it was not anticipated that any new technology existed which would make a major contribution to their present farming systems. This assumption was later confirmed. In 1977, Carangal noted that the best major cropping pattern for Cale appeared to be rice-corn.[13] It was grown in 1972 and had been for many years before.

In this initial phase of cropping systems research the emphasis was on understanding what the farmer is doing and developing a methodology to describe it. To ensure that the farmers' system was understood, many resources were committed to on-site data collection, both formal and informal. Daily record-keeping was started with fifty farmers. These farmers had been chosen from a stratified sample of the baseline survey of one hundred farmers. The daily record-keeping required the farmers to record each day any work they did related to crops. In addition, all inputs and products were recorded. Any cash transactions were noted, as well as estimates of home consumption of farm products. In addition to the farmers' records, village assistants were hired to time specific activities. The farmers were visited once or twice a week, depending on the amount of activity on the farm, to ensure that the data was complete and accurate. A rain gauge was set up to compare the rainfall with the nearest meteorological station 15 km away.

A set of simple experiments was established in the farmers' fields under their management to test the effect of higher levels of inputs. These tests were designed to find which factors of production might be underutilized in the present systems. For example, one portion of a field was kept weed free to find if there was a major gap between the current weed management and the highest level.

There was no concern with economics in these experiments. They were designed to find possible constraints in the present system. Once a constraint was found, the next step was to discover the reason for it. This step always started by a discussion with the farmers. Did they know a given input was limiting their yields? Almost invariably they knew but could not quantify the gap. The next questions were about the reasons for limiting the input. Although the farmers did not express it in those terms, they were usually making tradeoffs in the use of their scarce resources with other activities, or the risk was considered too great.

In the first years' data collection there were learning mistakes and a lot of recalls to verify and cross-check data. It was decided to continue for two more years to obtain year-to-year variations and to establish a data base large enough to develop an efficient methodology. There was a clear gap in the data collected, namely, the social factors that might be associated with the cropping patterns selected by the farmers. In early 1974, a survey of twenty-four barrios in Batangas covering 237 farmers was conducted.[14] All of the farmers keeping daily records were included in the survey to ensure the data base would be complete. In 1973 and 1974, a set of agronomy experiments were designed and conducted to find if certain patterns and management techniques could be varied and what the result would be. The summary of this work was reported but it was clear that there were still many questions regarding methodology.[15] The period 1972-74 brought about a change in emphasis and research. The work was clearly defined as a systems approach, and the first steps were taken to develop methods to understand the current farming systems.[16]

In addition to the site in Batangas, two more sites were selected in early 1975, one in the Province of Iloilo and the other in Pangasinan. These sites fell within the cropping systems objective of developing improved cropping patterns for small Asian rice farmers who grew rainfed lowland or upland rice. The rationale for choosing these farmers as the target group, was that irrigated farms had new technology and their income was relatively stable, while the rainfed farmer had little new technology available and little research had been done in this area.

Another major factor was that rainfed rice constitutes 59 percent of the rice land in South and Southeast Asia. The target group was over one-half the rice farmers. It was clear that IRRI could not cover the entire target group and so the value of a network to work on rainfed rice cropping patterns became evident. The agricultural scientists and policymakers in South and Southeast Asia were well aware of the rainfed rice problems and were happy to collaborate with IRRI to try and solve them.

In late 1974 and early 1975 the cropping systems program at IRRI went through a major change. The senior scientific staff was expanded from two to seven and the support resources expanded accordingly. The cropping systems program became the second largest program at IRRI. Why did IRRI move to a systems approach in such a large way and what, really, is systems research?

Systems Approach to Research

The concept of research based on a systems approach is not new in agriculture. Pliny noted that Roman farmers who used rotation cropping seemed to grow richer. Rothamstead station has shown that rotation is superior to monocropping for the last two hundred years. Men who studied the systems before them without a strong training in one discipline could see the interactions in a system. By the early 1900's research had started to move into disciplines and by the early 1950's was firmly entrenched. The sarcastic comment of Heady has the ring of truth in it:[17]

> Over time the tendency has been for disciplines to dig deeper moats around themselves and to retreat further into the departmental bastions; while physically adjacent, their deeper discipline barriers permit simultaneous attacks on the major facets of relevant problems in isolation. In fact, furtherance of the discipline typically is taken as more important than the solution of people's problems.

Many people were dissatisfied with the tight disciplinary approach, particularly those who were at the interface between the research and the farmer. The farmer viewed his farm as a system and had a working knowledge of the interactions of the present system. He could usually predict what the results of a change in one component of the system would be on the whole system. Most of the technology that came to him from research was considered and was found not to contribute to the system's over-all production. But, as Ebersohn observed in 1976, the research did not change--it became more specific.

> Increasingly detailed research is continually adding information on the components of agricultural systems. The effort is not being matched by synthesis of results into recipes that could be understood by farmers nor by predictions of the effect of adopted measures. These omissions have drawn crticism not only from farmers and their financing institutions who are left on their own devices to assemble the bits and pieces, but also from research administrators and scientists who are disappointed at the lack of impact their work makes on agricultural practice.[18]

By the mid 1970's, serious doubts were being voiced about strict discipline oriented research being able to solve the small farmers' problems. Based on its own experience and drawing from the experience of others, IRRI made a major commitment to systems research.

Systems research differs from traditional research in three major ways.[19] The first difference lies in the way a problem is approached and analyzed. When initially looking at the problem, the whole situation in which it is found is considered; this is known as a holistic approach. The immediate goal is not to reduce the problem to the smallest part that will give a mechanical type reaction. The interaction of the various components are noted in a systematic manner. Flow diagrams and matrices are two common ways of showing the interactions. The goal of the organization is taken as the end point. Then the various alternatives are considered based on intial conditions and end point wanted. The components of the system are combined in such a way that the goal is met efficiently. There can be no measure of efficiency if there is no goal defined.

Since most problems on a farm deal with a set of different types of parameters, no one discipline is usually capable of adequately defining the problem. Systems research is normative in most agricultural situations. The researcher makes a set of subjective assumptions on the goals, resources and synthesis of the components. These assumptions may be based on the best information available but they are subjective and another researcher with the same information may make a different decision.

The second major difference is that the selection of a research program is based on a systems basis. Through the use of a matrix or a flow diagram, some specific information is needed to show an interaction. If it is not known, and is considered important, finding that information becomes part of the research program. A systems approach identifies gaps in the data base. Evaluation of the need for missing data is subjective, but the criterion is its importance in relation to the final goal.

The third difference is that systems research is more likely to be efficient. Dillon gives three reasons from using a systems approach in research:

A. The research is more purposeful, there is less danger of working on the wrong problem, and there is a greater chance of recognizing and responding to research needs and opportunities
B. Better research management is facilitated
C. Agriculture is recognized for what it is--a hierarchy of systems with a purposeful nature.[20]

Heady also refers to the administration of research using a systems approach. "Administrative control could be viewed in the context of a matrix where the rows are problem sets and the columns are disciplines."[21] However, it would appear that the major reason for the efficiency of the systems approach is that an over-all goal is defined and each piece of research can be evaluated on what it could contribute toward reaching that goal.

There have been a variety of definitions put forward for the terminology used in agricultural systems research, particularly as it relates to research directly relating to a farm. In 1978, a review of the work being done on farming systems in the International Agricultural Research Centres was made by the Technical Advisory Committee for the Consultative Group on International Agricultural Research.[22] Their definitions will be used throughout this study.

> A farming system is not simply a collection of crops and animals to which one can apply this input or that and expect immediate results. Rather, it is a complicated interwoven mesh of soils, plants, animals, implements, workers, other inputs and environmental influences with the strands held and manipulated by a person called a farmer who, given his preferences and aspirations, attempts to produce output from the inputs and technology available to him. It is the farmer's unique understanding of his immediate environment, both natural and socio-economic, that results in his farming system.
>
> A system is defined as any set of elements or components that are interrelated and interact among themselves. Specifications of a system implies a boundary delimiting the system from its environment.
>
> Systems analysis refers to the holistic approach of studying the system as an entity made up of all its components and their interrelationships, together with relationships between the system

and its environment.

Cropping system refers to the set of crop systems making up the cropping activities of a farm system.

Crop system comprises all components required for the production of a particular crop and the interrelationships between them and the environment.

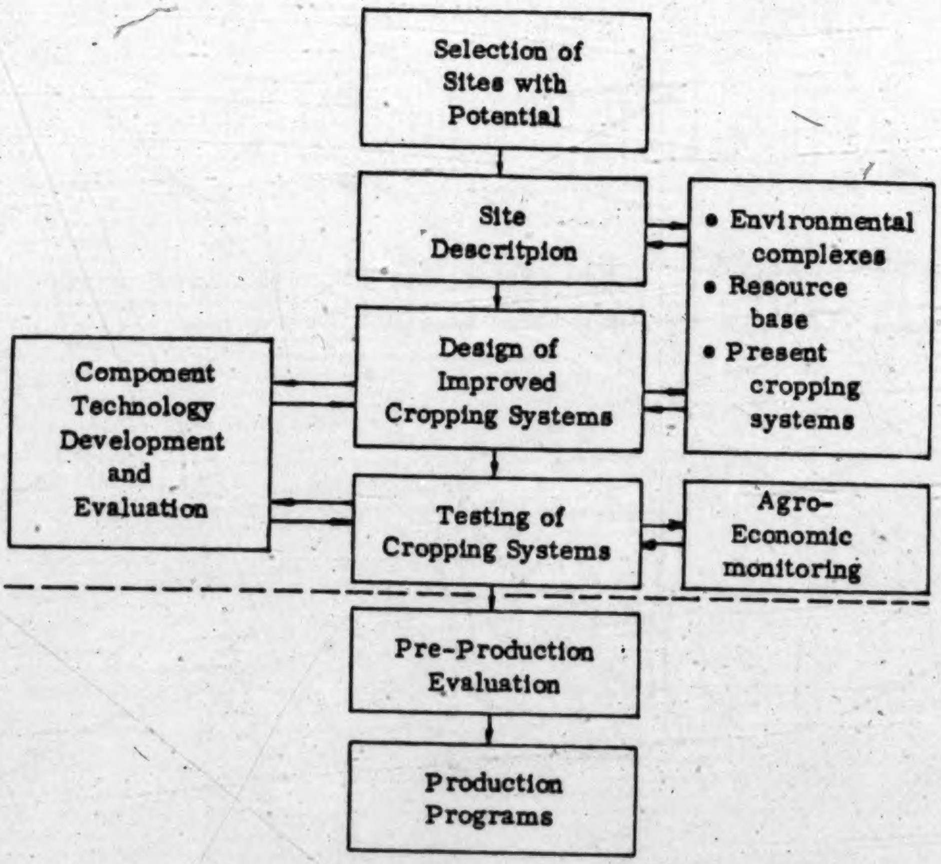
The Current Cropping Systems Program at IRRI

Utilizing the above definitions, the present cropping systems program at IRRI will be described. The goal is to increase food production through more productive rice-based cropping systems in South and Southeast Asia. To meet this goal, four specific objectives have been defined. First, to develop and extend research methodology in rice-based cropping systems; second, to feed back specific problems found in the program to the concerned group; third, to develop and test technology for agro-climatic zones similar to that of IRRI; and fourth, to encourage and assist national cropping systems research programs in specific agro-climatic zones.[23]

IRRI has divided the cropping systems research into five phases: (1) description, (2) design, (3) testing, (4) preproduction evaluation, and (5) production programs. (Figure III-1)[24] The descriptive phase is actually started before a research site is selected. Data is collected on soil characteristics, topography, rainfall patterns, current cropping systems, and temperature where applicable. This data is used in the final selection of a site. Once the site is selected, a baseline survey is done. This catalogues the resources available to the farmer and describes the present cropping system in some detail. A detailed listing is given by Banta.[25] This phase has two main functions. The first is to set out the situation found on arrival, so a comparison can be made later for evaluation to

FIGURE III-1

COMPONENTS OF THE CROPPING SYSTEMS
RESEARCH METHODOLOGY


Selection of Sites with Potential
Site Descritpion
• Environmental complexes
• Resource base
• Present cropping systems
Component Technology Development and Evaluation
Design of Improved Cropping Systems
Testing of Cropping Systems
Agro-Economic monitoring
Pre-Production Evaluation
Production Programs

determine if there have been any changes. The second, and more immediately useful function, is to serve as a guide where opportunities may lie for new technology, both from constraints and underutilization of resources in the present cropping system.

The design phase is the most critical in the whole research program. Here the knowledge of the different disciplines should be combined to produce a new cropping patterm for a given environment, with a given set of resources, that is more efficient than the present one. It is in this phase that lack of clear objectives and/or lack of knowledge show most clearly and can lead to major problems. When any one discipline cannot clearly communicate the parameters it is responsible for to the group, the pattern has less chance of meeting the objective set for it. The product of the design phase is a cropping pattern with all of the production techniques specified, a list of data to be collected and a set of alternatives if weather or other environmental factors change. The design phase may also include a set of component technology experiments to give specific answers to a problem or problems found or expected in a pattern.

These component technology experiments may be designed to be carried out on a research station, in a farmer's field under research management, or managed by the farmer in his field. The design phase can be divided into two. The first design occurs following the description of the site. It usually has a wide range of patterns, with the objective of finding what is possible. The second type of design occurs after an experiment is finished and the knowledge gained is put into use in designing the next experiment.

The testing phase is the actual production of the crops in farmers' fields, recording all major factors influencing its production and an analysis of the results.[26] While the crop is growing, all disciplines involved are monitoring the factors affecting the crops' growth and production. Although only one or two people may be in a field plot they may be recording soil moisture, root depth, solar radiation, rainfall, seedling vigour, weed index, insect numbers, disease index, man hours for an activity, inputs used, and the farmer's comments on what he thinks of the crop. This information is used by the different disciplines to evaluate the pattern. The individual evaluations are then brought together and a decision is made on the pattern. There are three possible decisions: the pattern is rejected and no further work will be done on it; the pattern is ready to pass to preproduction evaluation; or, the pattern has potential but more research is needed. If the latter decision is made it then goes back to the design phase. A pattern may go through the design and testing phases a number of times. All testing of patterns is done on farmers' fields under farmer management, although some time may be spent with the farmer if a new technique is being used in the pattern. One simple test of a pattern is adoption by farmers around the site. However, this is not always an acceptable test as they may try and fail, if they do not understand and follow the required methodology.

The preproduction evaluation is the final research phase. In this phase, the pattern is put out on 30 to 50 farmers' fields with a complete set of instructions. It is one last evaluation of the pattern, but the main objective is to find if the technology can be understood and used by the farmers. Also examined, is the changes they make, and if there are any major changes, why? Following this phase which lasts for only one year, the technology is ready for extension in production programs.

Asian Cropping Systems Network

The Asian Cropping Systems Network (ACSN) was started in 1974, with the enlargement of the program at IRRI. An agronomist was hired to act as Network Co-ordinator. His mandate was to assist program development in the ACSN and transfer ideas and methodology from one program to another. One of his major functions was to carry ideas from the ACSN to IRRI and vice versa. From the very start, it was considered important that there be a high level of interaction between IRRI and the ACSN. To ensure that this interaction would occur, specific measures were built into the programs of IRRI and collaborating countries.

First, it was decided to hold a working group meeting at least once every year. The working group, as the name implies, is composed only of those directly responsible for the cropping systems research in the ACSN. These are the program leaders from each country, plus the program leader and the network co-ordinator from IRRI. This makes a group of twelve people. These people have met eight times from 1974 to 1979. By keeping the group small and interacting regularly, an open and very clear line of communication has developed.

The meetings have been held in each of the collaborating countries, so the group would see firsthand the problems faced by that country. A regular part of the meetings is a tour of several of the sites in the host country. The results of the discussions are published and made available to all those working in the ACSN. The emphasis has been on getting the reports out quickly to keep people up-to-date on what has been happening rather than on turning out a top-quality publication. These working group meetings have had a very significant effect on the direction of IRRI's research and the methodology used in the country programs.

Since the program of each country has had outside assistance in funding, a special category for international travel has been included in all the budgets. This fund is used by the program leader to attend the working group meetings. There are additional funds for others working in the program to visit other countries to observe their programs. Monitoring tours are held once a year and organized by the network co-ordinator. Staff working at the sites are selected by the program leader to see what other researchers are doing, find out what problems they are having, and exchange ideas, solutions and new methodology.

Only people working directly with cropping systems programs go on these tours. The tours are informal with no formal presentations. These tours serve another purpose in addition to communicating ideas. They are a reward for field staff who have worked hard and normally would get no recognition for the site work they have done. Usually only high-ranking officials go on international trips. However, on this program, a new graduate with two years' experience, has a good chance of traveling and learning if he has worked productively.

A third area of interaction between IRRI and the ACSN is the six-month cropping systems training program at IRRI. This course is held every year for about thirty-five people who will be working at a site in a multidisciplinary team. It is designed for people who have a B.Sc. degree and at least one year's experience. The course is divided equally between field and classroom. Four areas are emphasized: agronomy, statistics, economics, and the concept of systems. Members of all the disciplines take the same course. The economists study how a crop grows and then go to the field and grow it. Agronomists struggle with marginality. The course is designed to meet the needs of the collaborating countries, and following suggestions at a working group meeting, was completely restructured in 1978.

Another type of training is the degree program. Through IRRI, students take their course work at the University of the Philippines at Los Banos, and then conduct their thesis work at IRRI with an IRRI scientist as advisor. Priority is given to young scientists directly involved in collaborative national programs. In 1977 there were fourteen M.S. and four Ph.D. students studying under the cropping systems program.[27]

Reference material is always a problem for a scientist in South and Southeast Asia. To assist the scientists in the ACSN, IRRI sends out copies of papers of cropping systems research. In 1977, twenty-four papers were sent to 257 scientists in the ACSN.

With the efforts of the network co-ordinator, plus the interaction of the working group, monitoring tours, formal and informal training, and distribution of reference material, there is a constant and very productive interaction between countries in ACSN.

> In the opinion of the Review Team, the formation of the Asian Cropping Systems Network has been the most significant development in cooperative programs between an IARC and its constituent countries. The collegial, collaborative mode of the ACSN--especially as regards program planning, development of methodology and program evaluation--is a key factor in the success of the network.[28]

The network has achieved the present level of success because all parties involved have gained from the involvement.

> The Review Team was particularly impressed with the value to IRRI and the national programs also of the Asian Cropping Systems Network, which appeared to be a truly joint and fruitful mechanism for cooperative planning and decision based on mutual respect and a recognition of partnership between the parties involved.[29]

Impact of the IRRI Cropping Systems Program

The IRRI Cropping Systems Program has had a major effect on agricultural research for the rainfed rice-growing areas of South and Southeast Asia. Some of these effects are quantifiable and others, perhaps the most important ones are not. The program has made researchers and policy makers aware of the systems approach. Since 1970, the IRRI Annual Report has had a section devoted to cropping systems. These reports are available in nearly every major agricultural library in South and Southeast Asia. The IRRI Reporter which goes to eleven thousand rice scientists and extension workers carries articles on cropping systems.

In 1977, over 11,500 people visited IRRI, and most of them were exposed to the cropping systems research. There are few agricultural scientists in South and Southeast Asia who have not heard of cropping systems. The IRRI program has played a major role in making the systems approach to agricultural research respectable. In the early 1970's after the cropping systems program was implemented and a major portion of its work moved to farmers' fields, there were grumblings that it should not be considered scientific research. As the research results started to appear, showing why single discipline results had not been accepted, the criticism started to die and the questioning started. Young scientists trained at IRRI started research in farmers' fields. Scientists who had never been off the research station except to tell farmers what to do, went to look, and found themselves discussing the research with farmers. It is hard to overestimate the impact that this interaction will have on research programs in the future.

Although each country, and even each research site in a country has a different organization the multidisciplinary approach is common to all. Throughout the ACSN the programs have been structured so that different disciplines work together on a set of patterns to help the small rainfed rice farmer. In any meetings or tours, IRRI ensures that all the disciplines discuss the problems together. The program has stressed not only the importance of a systems approach but has played a key role in making the approach operational in a variety of different government organizations in the ACSN. Without these non-quantifiable achievements of changing the thinking process and attitudes, the quantifiable achievements would mean little.

The IRRI program has developed a set of methodologies for conducting research on farmers' fields. Methodologies have been developed, and are being used for pattern testing using each farmer's field as a replication, for testing component technology, both farmer-managed and research-managed, and for multi-site testing of patterns. These methodologies for developing and testing component technology have significance not only for the cropping systems work but also for those working in a discipline approach who are supplying new technology.

A handbook on economic procedures to be used in cropping systems research has been compiled. This handbook has sections on surveys, record-keeping and analysis using different assumptions. The handbook assumes that the IRRI economic procedure has been used, that is a large baseline survey and fairly complete farm records for each farmer in addition to the records from the agronomic work. Although sections of the handbook have been used to solve specific problems by some in the network, it generally has not been widely adopted. Since it is a compilation of papers by various people, the style, approach, and complexity of the presentations differ. Those sections that have examples worked out are all from different sources, consequently there is a difficulty in following through the various examples. The handbook assumes sufficient resources are available to do a complete analysis from a full data base.

The IRRI program has made a major contribution in developing methodologies to define the physical and climatic environment for use in defining rice growing agro-climatic zones. These methodologies have been used by the ACSN countries to identify the boundaries of their target areas. The methodologies have also been used by policymakers in identifying high-priority areas for development in their countries.

In the long run, the development of the ACSN will probably be the major accomplishment of the IRRI program. In 1977, the ACSN directly involved the Philippines, Indonesia, Thailand, Sri Lanka, Bangladesh, and Nepal.[30] Other countries participating in the working group are India, South Korea, Burma and Malaysia. A listing of the sites with their environment and the target area is found in Table III-1.

TABLE III-1

DESCRIPTION OF CROPPING SYSTEMS NETWORK TEST SITES, 1977

Site	Kind of rice land	Immediate target area (ha)	Rainfall (no. consecutive months)		Soil texture	Soil suborder	Collaborators
			Wet	Dry			
Philippines							
Cale, Batangas	Upland rice	40,000	5	5	Clay loam	Udolls	Bureau of Plant Industry
Tigbauan and Oton, Iloilo	Rainfed-lowland, partially irrigated	300,000	5–6	2–4	Clay loam to heavy clay	Uderts	Bureau of Plant Industry
Manaoag, Pangasinan	Rainfed-lowland, partially irrigated	500,000	3–4 (low and high water table)	5–6	Clay loam	Aquept Aquents	Bureau of Plant Industry
Indonesia							
Lampung	Partially irrigated upland rice	1,500,000	5	4	Sandy loam	Aquults	Central Research Institute for Agriculture
Indramayu	Partially irrigated, irrigated	650,000	4	5	Clay loam	Aquents and Aquepts	Central Research Institute for
Thailand							
Pi Mai	Rainfed-lowland	850,000	2 (bimodal)	6	Sandy loam	Aquepts	Rice Division Department of Agriculture Division of Agricultural Economics
Ubon	Rainfed-lowland	500,000	3	6	Sandy loam	Aquults	Rice Division, Department of Agriculture Division of Agricultural Economics
In Buri	Irrigated and partially irrigated	500,000	2	6	Clay loam to heavy clay	Aquepts	Technical Division, Department of Agriculture, Division of Agricultural Economics
Bangpae	Rainfed-lowland	400,000	3	4	Silty clay loam	Aqualfs Aquepts	Kasetsart University
Sri Lanka							
Walagambahuwa	Partially irrigated (small tank)	101,000	3	4	Sandy loam	Aqualfs	Department of Agriculture
Katupota	Rainfed-lowland	25,000	2 + 2 (bimodal)	[illegible]	Sandy loam	Aquults	Department of Agriculture
Bangladesh							
Jovdepur	Rainfed-lowland, and irrigated	6,300,000	5	5	Clay loam to heavy clay	Aquents and Udults	Bangladesh Rice Research Institute
Nepal							
Parsa	Rainfed, partially irrigated, and irrigated	39,000	5	6	Sandy and silty clay loam	Aquepts	Agronomy Division, Department of Agriculture International Agricultural Development Service
Pundi Bhundi	Rainfed-lowland	50,000	7	2	Sandy and silty clay loam	Udults	Agronomy Division, Department of Agriculture International Agricultural Development Service

The fourteen sites have a total target area of over 11 million hectares. They fall in a continuum of rainfall and soil types. It is expected that by interpolation, new sites falling between these sites can use the research results as a basis and so quickly arrive at acceptable patterns with the package of technology needed. It is still too early to know if this can be done and on which factors it will be most successful. Except for Cale in Batangas, the sites are all lowland rice areas, some with partial irrigation. Partial irrigation refers to a system which supplements the rainfall in the rainy season and may prolong the growing season by a few weeks. Each of the sites outside the Philippines has been partially funded by an outside donor, principally the International Development Research Centre (IDRC) and the United States Agency for International Development (USAID). These sites have acted as the core for the national cropping systems programs. Indonesia, Thailand, Sri Lanka, Bangladesh, and the Philippines all have national programs. These programs are based on the concepts developed by IRRI, but adapted to the local situations. Each of these countries is starting or has in operation an in-country training program for people starting to work in cropping systems. IRRI's training role is slowly starting to change to training the trainers.

Future Directions of IRRI's Cropping Systems Program

For any program to be successful, it must look ahead and decide what needs it will meet in the future. In 1978, IRRI asked the working group to consider future needs of the ACSN and what role IRRI should play. The group's report was very clear and made a number of specific points. First they listed the goals of the program:[31]

1. to increase food production
2. to improve nutrition
3. to increase farmers' economic welfare
4. to increase farm employment opportunities
5. to improve the small-farm bargaining position
6. to aid national agricultural development programs.

These goals represent a consensus of the objectives of the national programs developed by the policymakers and researchers in each country. Naturally, the priorities varied from country to country but all agreed these were the goals. The group next discussed the approach being used to meet these goals:[32]

1. Agro-climatic classification
2. Site selection and description
3. Integration of physical, biological and soci-economic factors into a conceptual model
4. Site specific research
5. Preproduction evaluation
6. Production programs

From this approach it is clear that the IRRI-developed methodology is being used. However, the programs differ from IRRI in that the members of the group consider a program to be finished when it is in the production phase. It is also important that they note the importance of a conceptual model to ensure that those working in the program know where they fit in, what is needed from them, and what the goals are. The group then went on to discuss ways that IRRI could contribute to the national programs.[33] They concluded that IRRI could:

1. assist governments to adopt a cropping systems approach to agricultural

research

2. provide consultant services in different parts of the programs
3. train national research workers
4. help national programs get financial assistance from international donors
5. supply and exchange literature, technical, and plant material
6. exchange ideas and experiences through working group meetings, conferences, symposiums, monitoring tours and visits
7. conduct collaborative research
8. help evaluate the national programs.

A special point was made on the second item mentioned.

> It has been felt necessary that the IRRI cropping systems network should be further strengthened in terms of senior level manpower to provide adequate services to the country programs. Particularly, there is a felt need in the network for an experienced economist with a good background in cropping systems research.[34]

Although the program is a success it appears that there is a problem in the economic component.

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CHAPTER IV

METHODOLOGY AND ANALYTICAL PROCEDURES

The Field of Farm Management

This study is concerned with cropping systems research and ways in which the economic component can be of more assistance to Asian farmers. To achieve this objective, a framework is needed to better understand and analyze the farmer's current and potential decision-making situations. Farm management theory can supply such a framework.

Farm management is a special field of economics which considers the allocation of limited resources within the individual farm; it is a science of choice and decision-making; and thus, it is a field requiring studied judgment.[1] Farm management is based on a study of the farm from the farmer's point of view. It considers the farm as a unit composed of production and consumption aspects in continual interaction. Thus, farm management is based on a systems approach. It has two over-all goals: one, to push profits to the level consistent with the capital resources and abilities of the farm operator; and two, to relate choices in the farm operation to choices in the farm household in a manner consistent with the needs and wishes of the family.[2] To meet these goals, farm management cannot function in isolation. It interacts with other social sciences in understanding the social aspects of the farmer and his family in their environment. It interacts with biological and physical sciences in understanding and evaluating biological and physical processes. It uses evaluation criteria from the disciplines of Management and Production Economics. Farm Management's role is to synthesize knowledge from a variety of disciplines to help the farmer achieve the greatest possible benefit from his farm operation with the resources available to him.

The Role of Management Science in Farm Management

Management is concerned with achieving goals or objectives. There are several approaches to understanding and describing management. The approach selected depends upon the environment and the objectives.

The classical approach assumes there is one best way to achieve an objective and a set of rules should be laid down and followed to achieve this objective.[3] This approach may be considered when the operation is highly structured and there are very few uncertainties, e.g. building a fence.

The behavioural approach is people-oriented and assumes that if a man is encouraged to take additional responsibility and is given flexibility he will increase his productivity.[4] This approach has application in situations with limited structure and many uncertainties. This approach could be used, for instance, when organizing a research team.

Most managers use varying proportions of these two extremes, depending upon the environment and objectives. On most farms there are many alternatives and a high level of uncertainty. Farm Management tends, therefore, to put more emphasis on the second approach, helping the farmer understand his alternatives and make rational decisions to achieve his objectives.

The Management Process

Management is that part of human endeavour which guides the activities of individuals and organizations. It functions when decisions are made and actions taken in an attempt to reach goals in a world of uncertainty and scarce resources.[5] The functions of management are:

1. Recognition of a problem
2. Observation of relevant facts
3. Analysis and specification of alternatives
4. Choosing between alternatives (decision-making)
5. Taking action
6. Bearing responsibility for the action taken and re-evaluation

Recognition of a problem is the manager's acceptance that there is a gap between his present situation's likely outcome and his goal. Once this is accepted the next step is to collect information regarding the present situation and possible alternatives. When the information is collected it is analyzed in a manner which will allow comparison with the objective. Based on the results of this analysis, the manager makes a decision. He then takes action based on his decision and accepts responsibility for his action.

While decision-making is the heart of the management process, good decisions will not be made unless relevant facts surrounding the problem are carefully analyzed, and all the feasible alternatives considered. Furthermore, a good decision will not bear fruit unless it is implemented through action. Good decisions provide rewards to the manager, but any losses resulting from his decisions are also his to bear.

Evaluation of the outcome provides him with an opportunity to learn from his actions, and improve his managerial skills.

Objectives and Goals

Objectives and goals are the reference points for an individual to decide if he has a problem. The closer his situation is to a goal, the smaller the problem. In this study, objectives are defined as the long-run aspirations of the farmer. They are usually not thought of in specific quantitative terms. An objective might be to give his children a good education. Goals are more short-term and are usually thought of in more specific, quantitative terms. A goal might be to grow sufficient extra rice to pay school tuition of fifty dollars. The goals are usually intermediate steps to achieve an objective.[7]

Since all goals cannot be achieved at the same time a manager has a hierarchy of goals. Man's needs are in a hierarchy and Maslow defines them in descending order of importance as: physiological needs (food, water, and sex); safety needs (security, stability, and order); belonging and love needs (affection, affiliation and identification); esteem needs (prestige, success, and self-respect); and the need for self-actualization.[8] These needs can serve as a basis for a researcher considering the farmer's goals and objectives.

Decision-Making Process

Decision-making is an integral part of the management process. It is rarely a linear process; rather, it is iterative. With limited information an analysis is made, but it may be concluded that more information is needed before an acceptable alternative can be chosen. This cycle continues until the decision-maker is satisfied that additional study would cost more than the expected improvement in the alternative chosen. He then takes action.

The key factors in the decision-making process are:

1. a clear understanding of the goals and objectives by the decision-maker so priorities can be established
2. a clear definition of the problem
3. information shich supplies the analysis procedure with relevant facts
4. a logical and systematic analysis procedure
5. an eficient set of decision criteria

If any of these steps of decision-making is not followed the decision-maker lowers the probability of making a good decision.

The Role of Production Economics

While management science provides insights into the management and decision-making process, the field of economics, particularly production economics, provides the criteria which the decision-maker can use in the economic evaluation of farm mangement problems.

The basic problem in most farm management decisions is not only whether an alternative is profitable but more important, whether it is more profitable than the other feasible alternatives. The economic principles of production economics can supply the criteria on which to base this decision. Production economics put the technical and biological production information into an analytical framework and then applies costs and returns to provide answers to the questions: is it profitable? and, is it the most profitable alternative? The analytical framework used in production economics initially lays out the technical substitution ratios between resources, resources and their products, and between products. It then uses price ratios as the decision criteria, known as choice indicators. An example is the technical relationship between nitrogen fertilizer and a rice crop. When this relationship is known, the relative price of nitrogen fertilizer and rice are used to decide what rate will give the most profit.

The Basic Economic Decision in Production

A farmer achieves many of his goals by converting his resources--land, labour, and capital--into products at a profit. The more valuable the set of products he can produce from his resources, the more profit he can make and the more goals he can achieve.

To realize the greatest possible profit from his resources, a farmer uses the management process and economic criteria to make three basic decisions regarding the production process. They are:

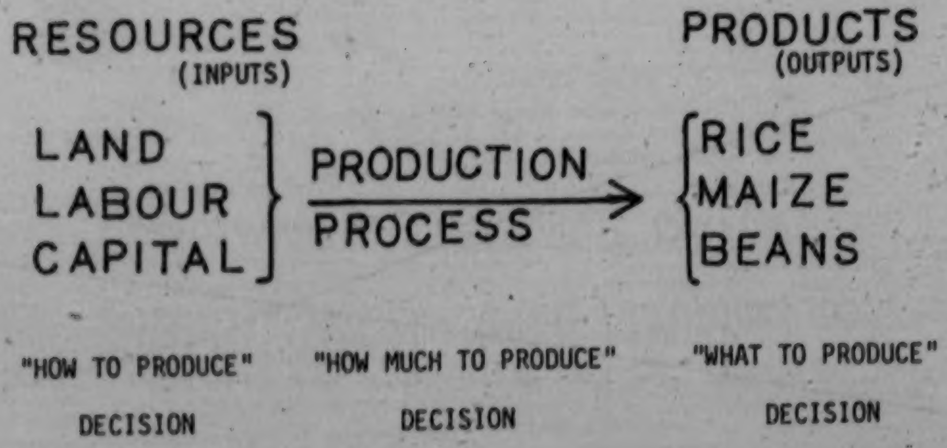
1. How much to produce?
2. How to produce?
3. What to produce?

In making these decisions the farmer decides on the kinds, amounts, and combinations of resources to use in the production process, and the kinds, amounts and combinations of products to produce. The relationship between the three decisions and the farmer's resources, production process and products are shown in Figure IV-1.

The "How to produce"decision deals with the combination of inputs. "How much to produce"relates to the production process. The combination of outputs is a result of the "What to produce" decision. Each of these decisions will be discussed.

FIGURE IV-1

BASIC PRODUCTION DECISIONS


RESOURCES
(INPUTS)
LAND
LABOUR
CAPITAL
PRODUCTION
PROCESS
PRODUCTS
(OUTPUTS)
RICE
MAIZE
BEANS
"HOW TO PRODUCE"
DECISION
"HOW MUCH TO PRODUCE"
DECISION
"WHAT TO PRODUCE"
DECISION

The "How much to produce" Decision

In deciding how much to produce the decision-maker is first concerned with the technical relationship between input and output. The farmer needs to know the effect of nitrogen fertilizer on rice yields before he can start to decide on its use. The technical relationship between input and output is known as a production function. A production function can be written in the form of an equation

$$Y = f(X_1 | X_2 - - - X_n)$$

This equation shows that the output Y, is a function, f. of a variable input X_1 with other inputs X_2 - - - X_n held at a constant level.

The relationship between the variable input and product can be presented in an equation or in a diagram. Most production functions related to biological processes have a sigmoid shape. A typical production function is shown in Figure IV-2. As increasing units of inpur X are applied, the TP curve increases first at an increasing rate, then at a decreasing rate, and finally decreases in absolute terms. This phenomenom is known as the "Principle of Diminishing Returns". This is a common characteristic of biological production functions.

The TP function can be further analyzed by deriving the AP and MP functions. The AP function is defined as $\angle Y/X$ and expresses the average production per unit of input of the variable X. The MP function on the other hand, is defined as $\angle Y/\angle X$, and expresses the rate of productivity change at a given point on the TP curve.

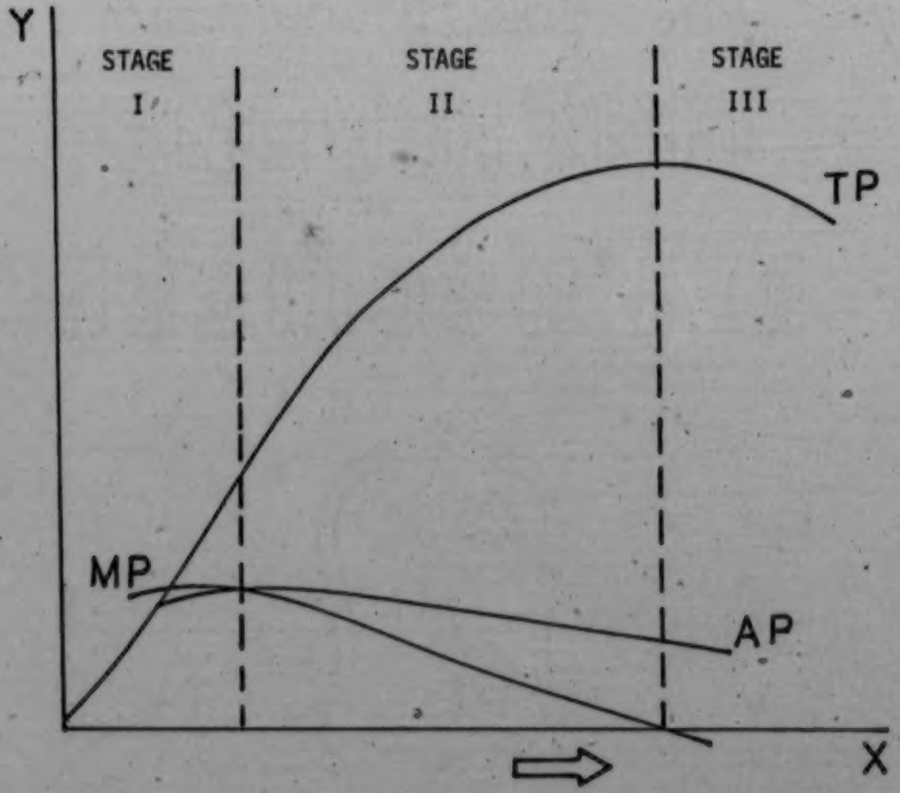
The production function can be divided into three stages as shown in Figure IV-2. Stage II is the only rational decision-making area. Stage III is irrational because more output can be obtained by using less input. Stage I is irrational because average returns per unit of input are increasing, consequently if the input pays at all, it will continue to pay better as long as the AP curve is rising. This leaves Stage II as the economic decision-making area of the simple production function. Stage II can also be described as that portion of the production function where MP is negatively sloped but greater than zero and less than the AP function.

It should be noted that a producer would only produce to the end of Stage II, where TP is at a maximum, when the input is free. On the other hand, if the input is severely rationed, he will apply it at a level consistent with the beginning of Stage II, when average product per unit of the input is the highest.

However the ratio $\angle Y/\angle X$ alone will not allow a decision

FIGURE IV-2

PRODUCTION FUNCTION WITH AVERAGE AND MARGINAL PRODUCTS



to be made within Stage II. Values of the input and output are needed. The ratio of these values is known as economic choice indicators. PX/PY is the price of a unit of input over the price of a unit of output. This ratio is used in Stage II to determine the optimum level of output. In Figure IV-3 the optimum level of output occurs when $\Delta Y / \Delta X = PX/PY$. By rearranging the equation the optimum level of output occurs when $\Delta Y \cdot PY = \Delta X \cdot PX$ or, added returns equal added costs. Often resources cannot be added in a continuous flow. If this is the situation, the optimum is reached when added returns are greater than or equal to added costs which can be written as $\Delta P \cdot PY \geqslant \Delta X \cdot PX$.

To maximize profit from an input-output relationship a decision-maker equates the input-output ratio with the inverse price ratio. As long as added returns are greater than or equal to the added costs, the farmer is ensured of making an economically desirable decision.

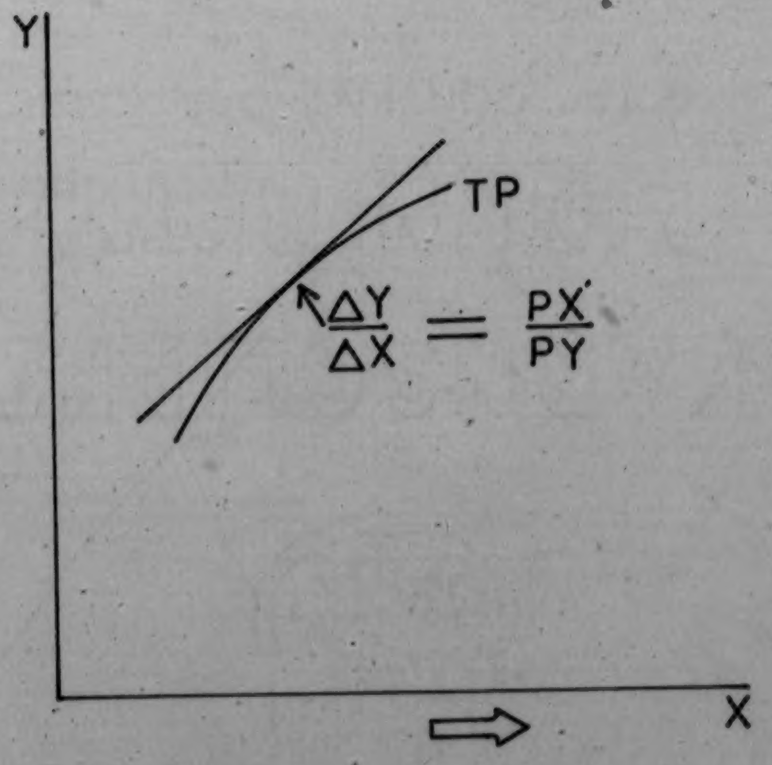
The "How to produce" Decision

When deciding how to produce an output, the decision-maker is concerned with the combination of inputs to produce a given output. There are three ways in which resources combine to produce a product, fixed proportions, constant rate of substitution, and decreasing rates of substitution. Inputs which combine in fixed proportions, such as a wooden plough and a man, require no decision about combination. A plough without a man will not affect production. Inputs which combine at a constant rate such as maize or sorghum in the diet of a chicken will not be used in combination. The most efficient decision will be to use all of one or the other. The reason will be explained in the next section.

Most inputs in agriculture have decreasing rates of substitution

FIGURE IV-3

INPUT-OUTPUT RELATIONSHIP WITH PRICE LINE


Y
TP
$\frac{\Delta Y}{\Delta X} = \frac{PX}{PY}$
X

and so are the most important. The isoproduct line in Figure IV-4 shows the decreasing rates of X_2 that will substitute for X_1. Land preparation hours could be represented by X_1 and weeding hours by X_2. As land preparation hours increase, fewer hours of weeding are needed to produce a given amount of rice. The ratio of $\Delta X_2/\Delta X_1$ is a technical relationship known as the marginal rate of substitution. It is the rate at which X_1 substitutes for X_2 for a given level of output. The marginal rate of substitution alone cannot be used to make a decision. Prices are needed. The economic choice indicator for input-input decisions is,

$$\Delta X_2/\Delta X_1 = PX_1/PX_2$$

the marginal rate of substitution equals the inverse price ratio. Rearranging the equation gives,

$$\Delta X_2 \cdot PX_2 = \Delta X_1 \cdot PX_1$$

the reduced cost equals the added cost. This same equation is used for deciding which input to use on inputs with constant rates of substitution Since the marginal rate of substitution is constant, comparing the reduced costs and added costs at any point will show which to use. In Figure IV-4 the equation is shown as reduced costs greater than or equal to added costs for discrete inputs which happen frequently in agriculture.

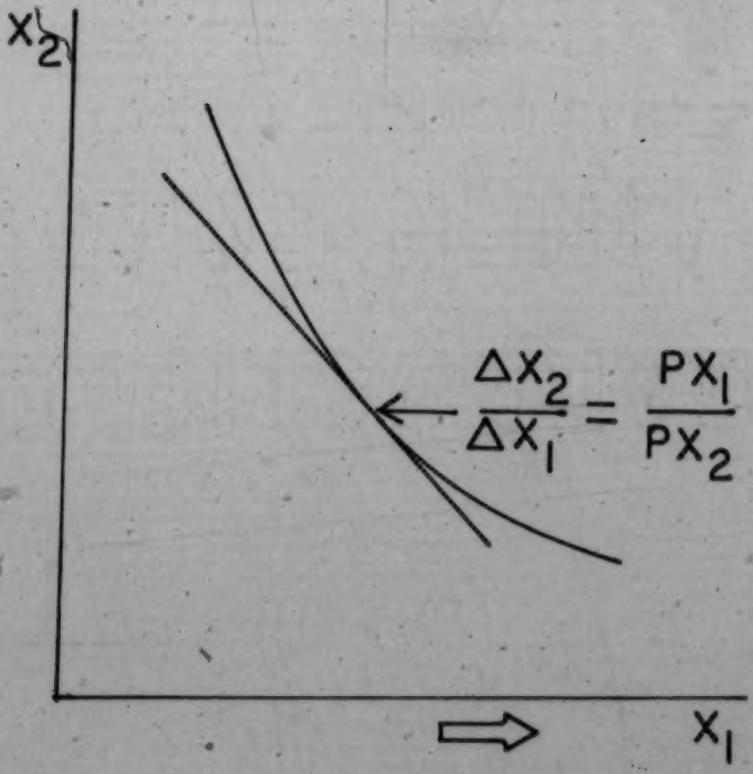
To minimize costs, a decision-maker equates the marginal rate of substitution with the inverse price ratio. By equating reduced costs and added returns, a farmer can make an efficient decision on how to produce.

The "What to Produce" Decision

A farmer has to make a decision on what portion of his farm to

FIGURE IV-4

INPUT-INPUT RELATIONSHIP WITH PRICE LINE


X_2
$\frac{\Delta X_2}{\Delta X_1} = \frac{PX_1}{PX_2}$
X_1

plant to rice and what to maize. This is an output-output decision. Outputs can have different types of interactions with each other. There are biological interactions which can be positive or negative. A legume-grain interaction is usually considered positive while cattle in a rice paddy is usually negative.

There are also economic interactions which can be beneficial or detrimental. A crop of maize after a crop of rice can be beneficial since most of the resources were not being used. A crop of maize at the same time as rice may be detrimental if few resources are available to grow either. The decision-maker must find the net effect of all the types of relationships.

There are three output relationships: complementary, supplementary, and competitive. In Figure IV-5 all three relationships are shown. A complementary relationship exists between AB on the isoresource line. As Y_1 increases, Y_2 increases also. This is an irrational area of production since more of both products can be produced with the same resources. BC shows a supplementary relationship as Y_1 increases, Y_2 continues at the same level. This also is an irrational area of production. A competitive relationship exists between C and D. It is in this area that an economic indicator is needed since an increase in Y_1 causes a decrease in Y_2. This relationship is referred to as the marginal rate of transformation, $\Delta Y_2/\Delta Y_1$. A competitive relationship is shown in Figure IV-6 with a choice indicator, the inverse price ratio line. The economic optimum is achieved when

$$\Delta Y_2/\Delta Y_1 = PY_1/PY_2$$

the marginal rate of transformation equals the inverse price ratio. The equation can also be written, $\Delta Y_2 \cdot PY_2 = \Delta Y_1 \cdot PY_1$ or reduced

FIGURE IV-5

ISORESOURCE LINE

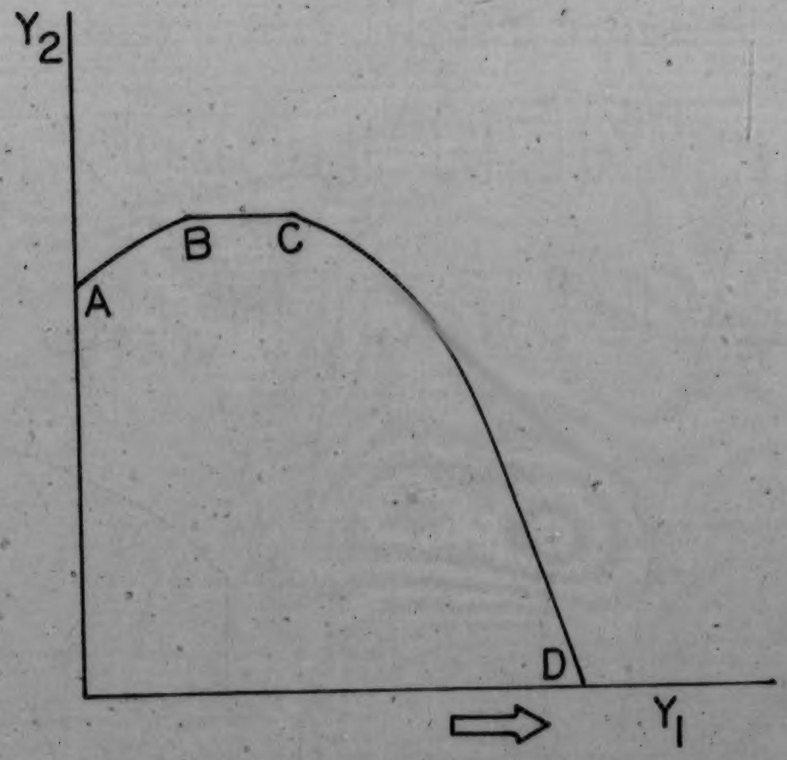
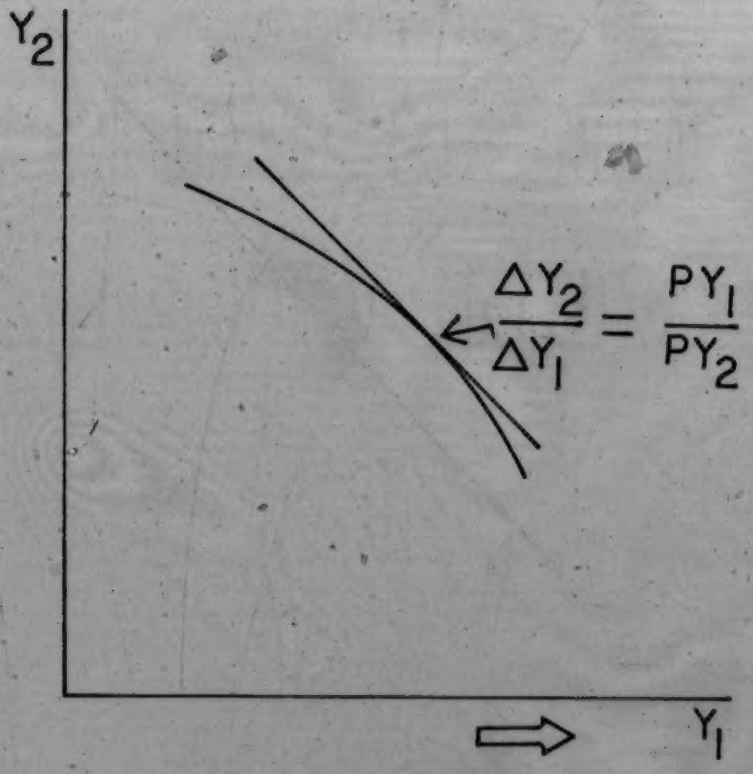


FIGURE IV-6

OUTPUT-OUTPUT RELATIONSHIP WITH PRICE LINE


Y_2
$\frac{\Delta Y_2}{\Delta Y_1} = \frac{PY_1}{PY_2}$
Y_1

returns are less than or equal of added returns. The inequality situation must be considered if the products are discrete.

The maximum profit from an output-output relationship is obtained when the marginal rate of transformation equals the inverse price ratio. The farmer who equates reduced returns with added returns will make the most efficient decision on what to produce.

The Principle of Opportunity Cost

When a resource is limited a decision criteria is needed to decide where it should be allocated and what value it should have. The question of value is particularly important for inputs, such as family labour, which are not usually bought or sold in the market. The principle of alternative opportunity cost can be used to make these decisions. Alternative opportunity cost of a resource is the return the resource can earn when put to its best alternative use. If the farmer can earn ten dollars a day working for his neighbour, the cost of working in his own field is ten dollars. The farmer then decides if working in his own field will pay ten dollars, or more. By using this principle the decision-maker can decide if the resource is being used most efficiently and if not, where it should be used.

The principle of alternative opportunity cost is important to the researcher as it is a method whereby values can be put on many inputs which do not enter the market place from a particular farm under study.

Dynamic Versus Static Analysis

All of the foregoing analyses are static. It is assumed that the production process is timeless and that the decision-maker knows with certainty all relationships and prices that will affect the production process. Neither of these assumptions is valid. Most production processes on a farm are biological and take time. Neither the farmer nor the researcher knows what the output will be nor what the value of the output will be at harvest. Agricultural production is a dynamic process; therefore, modifications and adjustments must be made to the choice indicators used in the static analyses previously discussed.

Time is an important factor in decision-making. There are two concepts that deal with time in decision-making. The first is discount or interest charges. A return of 100 dollars in ten years does not have the same value to a decision-maker as 100 dollars now. The future income is discounted to obtain a present value. The amount of the discount depends upon the alternative opportunity cost of money, which is usually the prevailing interest rate. A farmer deciding whether to plant maize or fruit trees could not make a rational decision without using a discount rate on the future income from the trees. In this study, time periods considered are nearly the same so discounting is not used.

The second concept of time deals with the flow of services from resources used in a production process. This concept has major implications in cropping systems research. The inputs required in a process may appear to be available when considered in total but the input use pattern may show that at a given time there is a constraint. Most farms show a surplus of labour over the year, but at planting and harvesting time many farms do not have sufficient labour. A graph showing inputs available and required at each point in time is an effective decision-making tool.

Most of the parameters in the static analyses discussed are unknowns. In deciding between alternatives the decision-maker does not know what output he will get from a given input, what the value of the output will be, what combination of inputs will give a certain output, and he may not know what the cost of the inputs will be when he takes action. An individual farmer faces many unknowns. The traditional approach to making decisions on unknowns has been to divide them into risk and uncertainty. When a decision-maker knows the possible outcomes of a production process, the probabilities associated with each outcome, it is known as risk, and an expected profit can be calculated.

Uncertainty occurs when the decision-maker does not know the possible outcomes. There is no generally accepted method of analysis. One method is to discount the expected profit by some arbitrary percentage. Recently, the concept of subjective probabilities has been more accepted in dealing with unknowns. Subjective probability is based on the degree of belief or strength of conviction a decision-maker has about a given outcome.[9] Thus, all outcomes are given a probability. The product of the expected outcome, and its probability is then used to choose among alternatives. In this study, it is assumed that the parameters are known or can be found.

The Present Status of Farm Management Economic Research

Up to the early 1960's, using the tools discussed previously, Farm Management made a significant contribution to solving farmers' problems. The objective of most of the work was to understand and help solve problems farmers were facing. By the mid-1960's, most production economists had access to computers and so could use sophisticated mathematical programming and econometric procedures. The emphasis in much of the production economics work shifted from solving farmers' problems to exploring the potential of the new procedures. Farm Management, which used production economics procedures, could make little use of this new work. The result was a growing level of frustration in the Farm Management discipline.

In his major review of farm management and production economics literature from 1946 to 1970, Jensen devotes twenty-two of the seventy-five pages to the question: "What is farm management, what is it doing, and where is it going?"[10] From his review, it is clear that there is a dichotomy between those who are trying to solve problems and those developing methodological and theoretical issues, mainly for their peer group. The latter dominate the literature. Basically everyone is developing ways to do the work but no one is doing it. The economic literature has been of little help to the ACSN economists.

> Given the need for technical data for farm production analysis and planning, it is something of a puzzle why comprehensive multidisciplinary efforts have not been more widespread and numerous.[11]

He suggests one possible explanation is that production economists turned to model building and linear programming and were willing to accept discrete data from physical scientists.

The economists working in cropping systems have had to develop their own methodologies and working procedures since the literature was of little help. They have run into many of the problems discussed in the literature before 1950, but never resolved. The literature has ignored many of the basic problems inherent in analysis of farm survey data.

Jensen calls much of the recent work into question.

> Given the problems of specification bias, intercorrelations among input categories, and problems growing out of aggregating inputs and outputs, it is questionable whether aggregate production function analysis should play any role beyond that of a diagnostic technique in the preliminary stages of analysis (i.e. for suggesting possible resource malallocation)[12]

In an article entitled "The Unproductive Productive Function", Upton reviews the assumptions and problems with farm production functions and concludes they are usually not worth doing for the solution of real world problems.[13] Although considerable advancement has been made in advanced mathematical and econometric procedures, there appears to be little help for the cropping systems economist trying to solve basic farm management problems. It would also appear from the literature that there is not likely to be much help in the immediate future. After reviewing twenty-five years of farm management and production economics literature Jensen had the following conclusion:

> Questions that need to be resolved in farm management are: What is management? What is to be managed? Who does the management? What is the unit of analysis? Who are the clientele? What are the decision criteria? What are the allocative principles? For if farm management is multidisciplinary and encompasses behavioral, social, biological and physical sciences or encompasses statistics, logic, sociology, home economics, psychology, philosophic value theory, physical and biological sciences and economics then an important additional question exists: Do these many disciplines exist as parallel fields, each with its own methodology, key variables and fundamental relationships, allocative principles, and decision criteria as these pertain to management in each discipline, or are there linkages among the variables from each discipline that tie the disciplines together into a general theory serving as a foundation for a managerial science? Or is the manager at one time a psychologist, at another time an agronomist, and at another time an economist?[14]

It is clear the economists in the ACSN are going to have to solve many of the problems themselves. The economists at the sites working with physical scientists and farmers are going to have to select which economic procedures are really useful in understanding the farmers' current system and comparing it with the new technology developed.

The Role of the Economist in Cropping Systems Research

Brief Review of Cropping Systems Research at IRRI

Economics is one discipline in the cropping systems program. To illustrate the role of economics and how it fits into the program, the current research approach, discussed in Chapter III, will be briefly reviewed.

The cropping systems research at IRRI and in the ACSN countries is based on a systems approach. This approach requires an understanding of the resources, interactions and goals of the organization under study. The organization under study in the ACSN is the Asian rice farmer. The farmer's resources and the interactions which take place on his farm fall under a variety of different discipline studies. Rather than have one discipline try to study the whole system, the various disciplines are brought together to study the system. A group of scientists working together to try to solve a single problem set is referred to as a multidisciplinary team conducting interdisciplinary research. A multidisciplinary team can be the most effective method for studying cropping systems. As previously mentioned, cropping systems research has been divided into five phases. In this study only the first three phases of cropping systems research are considered: describing the present cropping systen in a given environment; designing new technology; and testing the new technology using the criteria, "Will it help meet the farmers' needs?" The first phase is considered in this study only as it affects the second and third phases. So for purposes of this study, the objective of the team is the design and testing of new cropping patterns and the related technology to meet the farmers' needs in a given environment.

Each member of the group has a responsibility to contribute the knowledge of his discipline to the design and testing phases of the research. This study is primarily concerned with the economists' contribution to these phases of the research. Economics is concerned with the allocation of scarce resources to meet man' needs as fully as possible. The economist's role is to help design experiments which will test the efficient use of the farmers' scarce resources in different cropping patterns and evaluate the results using economic procedures.

In order to make the greatest possible contribution, the economist must be able to interact with the other team members. This means he must understand economics well enough to explain it in language all can understand. He must have a good grasp of basic agricultural technology. He must be able to conceptualize and organize the economic research component of the research program. The demands on an economist working in a cropping systems program are greater than if he were working in a single discipline program. Economists with a background such as this are rare, so most programs have young economists who are learning on the job.

Reference materials are very important. The cropping systems network has been making available to each country results of the work done at IRRI and in other ACSN countries. But access to literature from outside the network is generally limited. Budget constraints and the increasing cost of books and journals has meant limited reference materials in most programs. Equipment to assist in data analysis has been lacking. In the past, many economists have not had a constantly available hand calculator. Often one was shared between two or three people from different disciplines. Recently, funding agencies have been supplying simple, battery-operated hand calculators. At most sites now there is a young economist with a hand calculator and very limited reference material.

The methodology used in most of the programs is based on the methodology used at IRRI,--a baseline survey of about 100 farmers with 300 to 500 questions per farmer, then detailed record-keeping of farm or cropping activities on thirty to fifty farms during each year the site is in operation. On each farm there are about eight crops per year and about thirty observations per crop. Assuming only 300 questions on the baseline and forty farmers per site the first year, there are at least 40,000 data points. This does not include any household or non-crop activities, any results from the agronomic work, nor any price or rainfall data. Thus, in the first year there are likely to be 50,000 data points for a young economist with a hand calculator.

Site Study of Economists' Activities

In 1979, a questionnaire was mailed to five countries to gain a clearer understanding of what procedures the economists are using, which economists are doing the work, and what the economists' backgrounds are. The countries were Bangladesh, Indonesia, Philippines, Sri Lanka, and Thailand, all of whom have had programs in cropping systems for over three years. A total of twenty-two sites were covered by the survey, all having been in operation at least eighteen months. (Table IV-1)

TABLE IV-1

SUMMARY OF ECONOMIC DATA COLLECTION AND ANALYSIS ACTIVITIES AT 22 ASIAN CROPPING SYSTEMS SITES

	Head quarters	Head quarters Site	Site	Not Done	Mean months to complete
Baseline					8
Farm Records					
Data collection	0	0	16	6	
Weekly or monthly summary	6	3	7	6	
Calculate means of inputs	6	1	8	7	
Calculate S.D. of inputs	6	1	2	12	
Cross tabulation	6	3	7	6	
Cost and return	8	4	4	6	9
Return to factors of production	8	3	4	7	
Production function	0	3	0	19	
Labour distribution analysis	5	5	2	10	
Cash flow analysis	4	2	2	14	
Whole farm budget	0	3	0	19	
Agro-Economic Experiments					
Data collection	2	1	17	2	
Cost and returns	5	5	5	7	7
Return to factors of production	6	4	5	7	
Man Years per site					
M.Sc. or Ph.D	0.2		0		
B.Sc.	0.5		0.7		
High School	0.1		1.4		

All twenty-two sites had undertaken a baseline survey but five had not completed the analysis after eighteen or more months. Ten sites finished the analysis in five or more months. Seven were finished in four months but three of these used less than one half of the data collected in the analysis. Thus, most of the data collected did not formally help in planning the first year's work and left the economists with a backlog of work just as the program was starting.

The on-going work of the economists can be divided into two areas, farm record-keeping and agro-economic experiments. Six sites did no farm record-keeping. Of the sixteen where farm record-keeping was done, all did costs and returns, fifteen did returns to factors of production, twelve calculated labour distributions, and eight cash flows. Only the IRRI sites calculated production functions and tried some whole-farm budgeting. Only nine sites calculated the standard deviation of the input means. In the last full year of research only five sites completed farm record-keeping cost and returns in four or less months. Four of the five sites that completed the results in four months or less did the analysis on-site.

The questionnaires further revealed that two sites did not collect economic data from the agronomy experiments in the last full year of research. Of the twenty sites that collected some data, only fifteen calculated costs and returns. These same fifteen also calculated returns to factors of production. The main reason that the five sites collected data but did no analysis was crop failure. Four sites completed costs and returns analysis of the agronomy experiments in four months or less. Most took five months and two took over one year. All four sites that finished in four months or less did the analysis on-site.

An analysis of the man-years spent on the economics of cropping systems shows 2.1 at the site, and o.8 at headquarters, for a total of nearly three people per site. The educational level of the people averaged 0.7 with B.Sc., and 1.4 with high school at the site. At headquarters, the educational breakdown per site was 0.2 with Ph.D. or M.Sc., 0.5 with B.Sc., and 0.1 with high school. The problem does not appear to be lack of manpower, considering other programs which are functioning with far less manpower and conducting economic research. Another important factor is that as new sites were started, additional staff was placed at the site, but no new staff was added at headquarters. Although the initial trend showed more analysis being moved to headquarters, it is clear this cannot go on for long. If a major national program were started, headquarters could not handle the analysis.

The economic components' formal results have been of limited use in the basic objective of cropping systems research, that is, designing new cropping patterns and the technology needed to increase farmers' productivity. The results come out late and cannot be used in the design phase of the program for the next year. The results are usually only for a single pattern and no attempt is made to combine patterns for a given farm situation. A few sites have labour and cash flows but little use is made of these in further analysis or explaining the implications for further work.

The process now in operation at most sites leads to a continual buildup of data to be analyzed and a growing frustration among the economists and others in the cropping systems research program. The frustration stems from several sources. Having to go back and check mistakes in data over a year old is very slow and gets limited results if any. Telling agronomists their input levels are not efficient after the crop is harvested, lowers the level of social intercourse for some time. The economist sees the growing backlog of work and knows he is adding to his own problem by collecting more data. Many economists at the site have little opportunity to do any analysis but costs and returns and so do not develop their skills, resulting in a feeling they are not progressing in their profession. The basic problem in the process is that there is an imbalance between data collection and analysis time. The economist does not know what data to stop collecting. Since the systems approach stresses understanding the complete system the economist is afraid he will miss some important data.

Economic Analytical Procedures

Given that the economists in the cropping systems teams will be using the basic choice indicators previously discussed, and that the current methodology is not proving satisfactory, the next step is to review economic analytical procedures which are being used and those that could be.

Few economic problems are so simple and clear-cut that one approach can be used to solve them. There is usually a sequence of decisions that must be made to arrive at the most efficient alternative. A farm management researcher using production economic tools has a range of procedure to choose from. As already discussed, his choice depends upon resources available, skill of the researcher, type of problem and who the clients are.

There are two general types of procedures available which will be called (1) formal and (2) informal. There is no clear-cut line dividing them and the same choice indicators may be used in both general procedures. The main difference is that the formal procedures have a set of rules that must be followed in the analysis, while the informal procedures are more flexible and leave many of the decision to the researcher's judgment. The latter procedure is more subjective, but allows for more learning on the part of the researcher.

Formal Procedures

The two most commonly used formal procedures are econometric-based production function analysis and linear programming. Each of these procedures has been developed with a complete set of mathematical rules governing its use and solution. Because of the strict set of rules governing their solution both procedures can be solved by standard computer routines. This feature has meant a great saving in resources for researchers. The computer can handle masses of data with great precision. Unfortunately, precision and accuracy can be confused. The ease of computation has allowed a person who has little understanding of a production process to produce very precise solutions which may be inaccurate. The basic concepts of each procedure will be discussed in turn.

Production Functions

Production functions, when used in economic analysis and recommendations, can provide one of the two sets of information needed for choice and decision-making.[15] The other set of information needed is the prices of inputs and outputs. A production function defines the technological relationship between inputs and output of a given production process. A production function usually shows only the inputs under consideration and assumes a given set of other resources. In cropping systems, production functions are used for several reasons: first, as a means of evaluating current and future use of resources; second, to study the efficiency of new technology. Before a production function is used a set of basic assumptions must be considered:

1. the production process is independent and additive
2. the number of inputs is finite and can be cardinally measured
3 the inputs are independent
4. a given input is homogeneous
5. the output is homogeneous
6. the output is cardinally measurable
7. the production period is long enough to include all input and output flows, and
8. the production period is short enough to exclude any technological or environmental changes.

Two of these assumptions, input independence and homogeneity have major implications for cropping systems research. If the inputs are not independent and homogeneous the reliability of the product function is questionable since these two assumptions are basic to least squares regression analysis. These two assumptions will be examined in Chapter V.

Linear Programming

Linear Programming is the analysis of problems in which a linear objective function of a number of variables is to be maximized (or minimized), when those variables are subject to a number of restraints in the form of linear inequalities.[17] The objective of linear programming is to find the maximum (or minimum) in a given situation. The linear objective function is composed of the factors considered to be relevant to achieving the goal. One or more of the factors must be limited. Each limitation or set of limitations is shown in a separate equation. One further restriction is that no factor can have a negative quantity. There is no limit on the number of factors that can be included. Data availability and computational time usually act as the limitations. Numerous articles and books on linear programming are available with detailed explanations. One that is based on farm management problems is by Heady and Candler.[18]

Informal Procedures

There is a wide variety of informal procedures used in economic analysis ranging from quick guesses to simulation models developed from gambling games played with farmers. They all have one thing in common: the researcher's opinions and decisions are a definite part of the solution process, unlike linear programming, which has a specific set of mathematical rules. Thus, the researcher's intuitive knowledge can be used throughout the decision-making process. Using informal procedures no two economists are likely to get the same precise solution starting from the same data base. However, if both have a clear understanding of the goals and the alternatives they are likely to arrive at the same conclusions.

The economist at the site has learned a lot about the current-cropping system from his discussions with the farmers. Much of this information is never recorded. The economist has a wealth of informal knowledge which he can contribute to the design phase. There is no easy way to quantify this information but the more time the economist spends with the farmers, the more complete his understanding of the system. By interacting with the other disciplines at the site, advances can be made which will not show in the data from that year's work. This is one of the main strengths of the site approach to research. Since Agricultural Economics still has many problems to resolve before a clear formal analytical procedure can be provided, the importance of the economist's informal understanding and input can hardly be underestimated.

The procedures to be discussed in this section are based on the premise that an approximate answer on time is of more use than a precise answer that arrives too late. Thus, the procedures to be used in evaluating the design phase of cropping systems research will be simple and informal. The simplified procedure will have a set of sequential steps. Each step will result in an answer on which decisions can be made. After each step, those cropping patterns or components of a pattern found not to be as efficient as others are dropped from further analysis. The sequence will lead to a final decision on whether the research under investigation is likely to lead to an increase in the farmer's well-being through meeting his needs. Is it worthwhile? is the question which should be answered at each step of the analysis. The procedures can be divided into three stages: budgeting, graphing, and program planning. An example of the three-stage process is given later.

In the budgeting stage the new technology will be compared with the current technology it is to replace. If it is found more profitable, it is carried on to the next step which is graphs. Graphs of resources used over time will show if there is a constraint and, if so, where it occurs. If it is found that there is no major constraint the economic analysis is finished. If there is a constraint, the new technology is analyzed by program planning, to find if it is likely to fit into the current farm operation and, if so to what extent.

Partial Budgets

A partial budget provides a framework to make decision on the three basic production economic problems: how much to produce, how to produce, and what to produce.[19] It has a strong grounding in marginal analysis discussed earlier.

> A budget is defined as an estimation of possible changes in costs and returns in a given time period when there is a contemplated change in the use of production resources.[20]

The general format used in partial budgeting is:

ADDED COSTS	ADDED RETURNS
REDUCED RETURNS	REDUCED COSTS
ECONOMIC DISADVANTAGES	ECONOMIC ADVANTAGES

In marginal analysis the decision on how much to produce is made by the relationship $\Delta X \cdot PX \leq \Delta Y \cdot PY$. In partial budgets this decision is made by the relationship:

$$\text{ADDED COSTS} \leq \text{ADDED RETURNS}$$

The decision on how to produce in marginal analysis is made by equating $\Delta X_1 \cdot PX_1 \leq \Delta X_2 \cdot PX_2$. Using partial budgets this is given by

$$\text{ADDED COSTS} \leq \text{REDUCED COSTS}$$

The decision on what to produce is made by equating $\Delta Y_2 \cdot PY_2 \leq \Delta Y_1 \cdot PY_1$ in marginal analysis. Partial budgets supply the decision by equating

$$\text{REDUCED RETURNS} \leq \text{ADDED RETURNS.}$$

In addition to these specific analyses, the partial budget can be used to compare the complete effect of an alternative by using all six components of the format. If the economic disadvantage is larger than the economic advantage, no change should be made.

When partial budgeting is being used to compare an alternative, all of the changes in costs and returns must be included. One of the weaknesses of partial budgeting is that the format is so simple, it can lead to hastily thought-through analysis, with the resulting inaccurate conclusions. It should also be noted that although based on the marginal concept, partial budgeting differs slightly from marginal analysis. Partial budgets use the total added and total reduced values, while marginal analysis considers only the last unit of change. Thus, there is a difference in precision, particularly if the changes are large.

A hypothetical example of partial budgeting. A farmer has sufficient lowland to grow the rice his family needs. He has an additional twenty hectares of land that is in sugar cane. The price of sugar cane is falling, and he is looking for alternatives. Cropping systems experiments have been conducted on similar upland areas. The crops tested were rice, mung bean, maize, sorghum and tomatoes. Should he stop growing sugar cane and switch? If so, to what?

The first step is to find if the new crops are more profitable than sugar cane. Table IV-2 shows the gross returns and variable costs associated with each crop. With the information from Table IV-2 a set of partial budgets can be used to find which crops are more profitable than sugar cane. (Table IV-3) In the comparison of sugar cane and rice, the rice will be added and the sugar cane removed. The added costs are the costs that will be incurred in growing rice. The reduced returns is the loss in income due to sugar cane not being grown. The economic disadvantage is the sum of the two. The added returns come from the rice and the reduced costs are the costs saved by not growing sugar cane. The sum of these two is the economic advantage of switching from sugar cane

TABLE IV-2

GROSS RETURNS AND VARIABLE COSTS: AN EXAMPLE ($/Ha)

	Variable Cost	Gross Returns
Sugar Cane	260	300
Rice	70	150
Mung bean	10	60
Maize	200	250
Sorghum	70	100
Tomatoes	400	600

to rice. A comparison of the economic advantage and disadvantage values allows a decision to be made. In this case, the alternative is more profitable. The same procedure is used for each of the alternative crops. All the crops but sorghum are more profitable than sugar cane. Sorghum is dropped from the analysis, and analysis is started on the next step in the procedure.

TABLE IV-3

EXAMPLE OF PARTIAL BUDGETS ($/ha)

Comparison of Sugar Cane and Rice			
Added Costs	70	Added Returns	150
Reduced Returns	300	Reduced Costs	260
Economic Disadvantage	370	Economic Advantage	410
Comparison of Sugar Cane and Mung Bean			
Added Costs	10	Added Returns	60
Reduced Returns	300	Reduced Costs	260
Economic Disadvantage	310	Economic Advantage	320
Comparison of Sugar Cane and Maize			
Added Costs	200	Added Returns	250
Reduced Returns	300	Reduced Costs	260
Economic Disadvantage	500	Economic Advantage	510
Comparison of Sugar Cane and Sorghum			
Added Costs	70	Added Returns	100
Reduced Returns	300	Reduced Costs	260
Economic Disadvantage	370	Economic Advantage	360
Comparison of Sugar Cane and Tomatoes			
Added Costs	400	Added Returns	600
Reduced Returns	300	Reduced Costs	260
Economic Disadvantage	700	Economic Advantage	860

Graphing

The next set of analytical procedures utilize graphs to study resource use over time. These analytical procedures have three functions:

1. to remove any technologies which have a resource use pattern that cannot be met by the farmers' resources even if used on a relatively small scale
2. to show resource use levels over time so new technology can be designed to either even out the resource flow for those resources which give a flow of service, or make greater use of resources which would be or are underutilized, and
3. to detect the specific periods when resource constraints appear. These resource constraints at a specific time are used for the next set of analytical procedures.

The use of each resource in a production process will be put on a graph with time on the X axis and resource uses per unit time, per set of other resources on the Y axis. Using the resource base assumed for the farmer from the data collected, constraints for that resource at a specific time period will be found. If the resource is considered a stock, that is, can all be used at one point in time, a calculation will be made on what portion of the resource could be utilized by the new technology. If it is found that the new technology uses more of a resource than the current technology it is expected to replace, a major constraint has been found. This constraint will be carried over to the next step in the analysis. A second major use of these diagrams is to show where resources are underutilized in both the current and proposed systems. Two additional graphs can be used but are optional. These graphs would show the flow of cash and rice over the year. The current system's flow would be shown and then the expected flow from the new technology could be superimposed. Any major deficiencies or lags would be clearly noted.

A hypothetical example of graphing. In the partial budget example it was found that rice, mung bean, maize, and tomatoes are more profitable than sugar cane. The next step is to find if the farmer can grow them with the resources available to him.

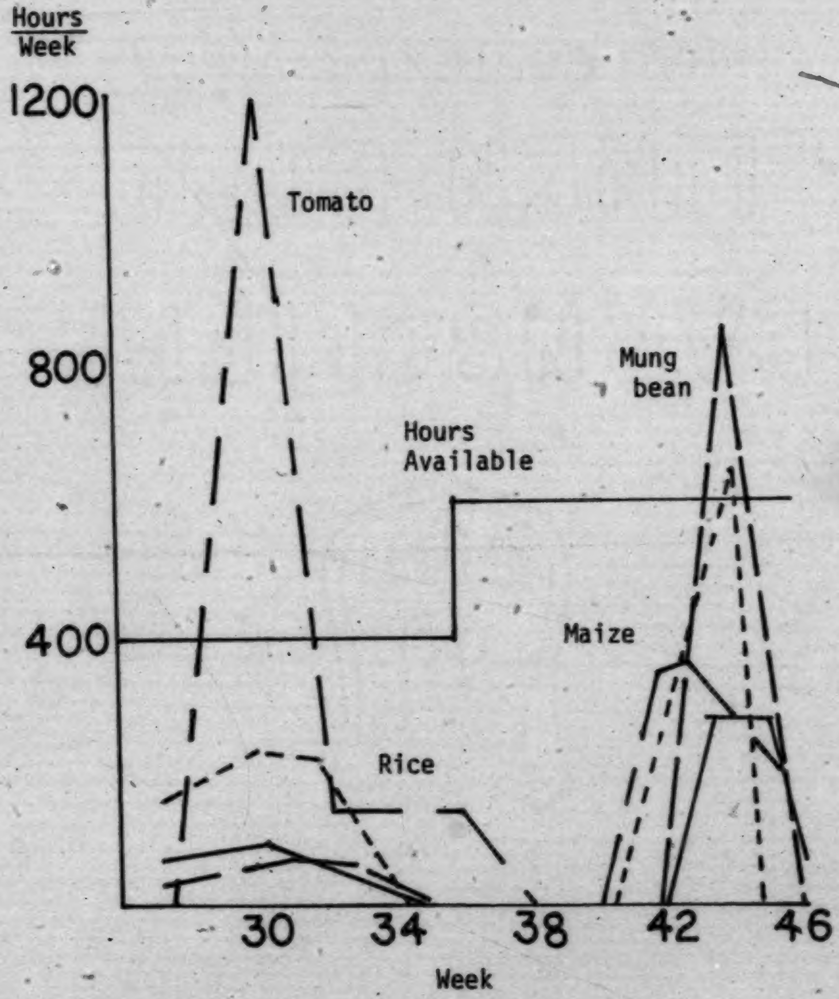
The farmer has $1,500 available to purchase seed, fertilizer and chemicals at the start of the season. There is no cash income between planting and harvesting, so cash can be considered a stock of resources. When a resource is a stock there is no need for a graph. Simply dividing the resources required per unit into the total stock of resources will show if there is a limitation and if so, how many units can be produced. The cash costs of production are rice $50, mung bean $10, maize $100, and tomatoes $300. By dividing each of these into $1,500, only maize and tomatoes cannot be grown on twenty hectares. Maize can be grown on fifteen hectares and tomatoes on five hectares. The farmer does not see the five hectares of tomatoes as a constraint as he has no intention of planting more than one hectare of tomatoes. Thus, there is a fifteen hectare cash limitation on maize and a one hectare management limitation on tomatoes.

The next resource to consider is labour. Labour gives off a flow of services that are either used or lost. It cannot be stored. In Figure IV-7 the labour use requirements for each crop are shown over their production period.

There are two time periods when labour is a limiting factor--weeks thirty and forty-four. Tomato can only be grown on a small area

FIGURE IV-7

LABOUR HOURS FOR TWENTY HECTARES EXAMPLE



due to the labour limitation in week thirty. Mung bean and maize cannot be grown on all twenty hectares due to labour limitations in week forty-four. At this point, a subjective decision must be made: should tomato be rejected completely? The decision is not to, since it showed the highest profit and the farmer would only be willing to grow one hectare. From this graph it can be seen that rice is the only crop that can be grown on all twenty hectares. But rice had a low profit so the decision is made not to discard any of the alternative crops due to labour limitations. The decision implicitly assumes a combination of crops will be grown.

Animal power is another resource which gives off a flow of services. It is handled the same as labour. Animal power is only needed for land preparation, so the time period when it must be analyzed is much shorter. (Figure IV-8)

There is a major limitation in week twenty-eight for animal power on rice. Only one half of the twenty hectares can be planted to rice due to this limitation. Maize uses all of the animal power if planted on the twenty hectares. Animal power in week twenty-eight is another limitation. No crops have been discarded in this stage.

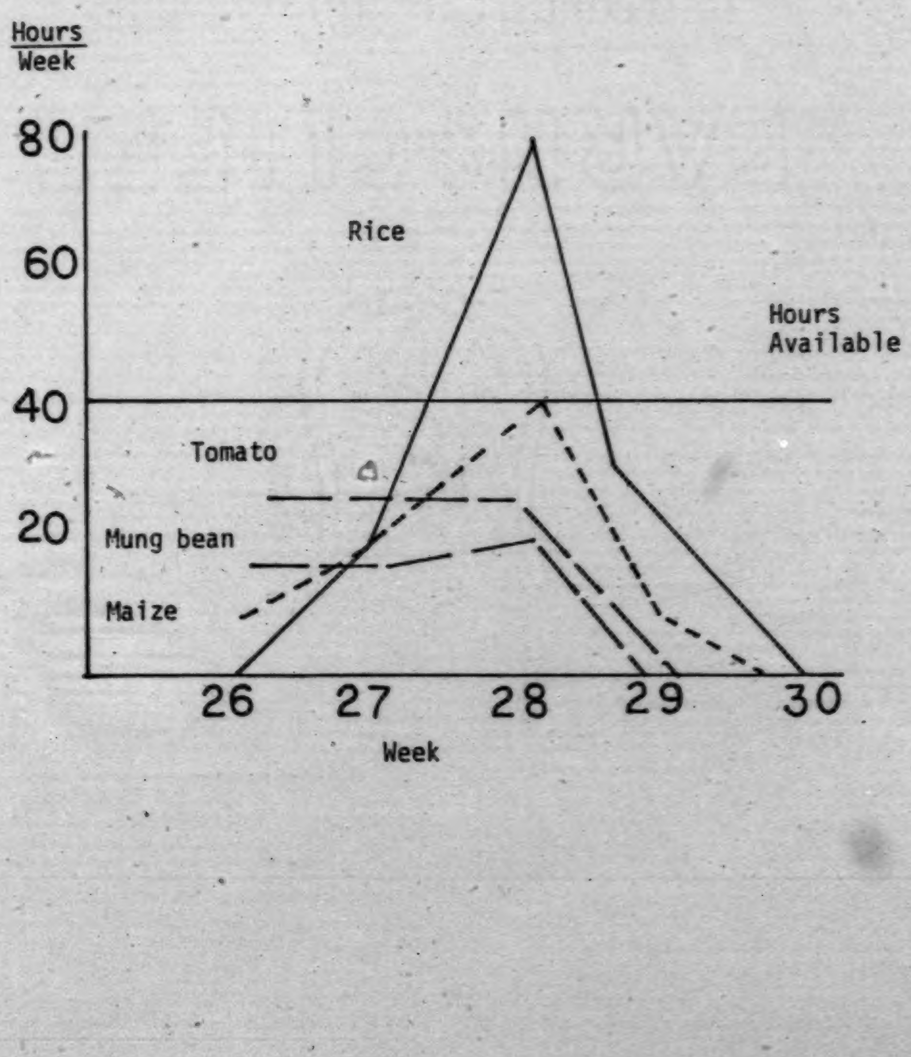
Limitations have been identified for the next stage. They are cash for tomatoes and maize, labour in week thirty for tomatoes, labour in week forty-four for mung bean and maize, and animal power in week twenty-eight for rice. In addition, the farmer has put a limit of one hectare on tomatoes.

Program Planning

The third stage of the procedure is to use approximation methods to obtain an optimum or near optimum combination of resources. Approxi-

FIGURE IV-8

ANIMAL HOURS FOR TWENTY HECTARES EXAMPLE



mating methods go under a variety of names, program planning,[21] simplified programming,[22] and heuristic programming.[23] In this study the term "program planning" will be used. The concept was first made workable at the University of Minnesota in 1957,[24] however, it did not receive much attention in the literature due to the emphasis on LP models and large computers. By the early 1960's a variety of approximation procedures had been developed and put into use. Some of these procedures were reviewed by McFarquhar in 1962.[25] Since the mid-1960's, little has appeared in English agricultural economics literature. However, industrial engineering and management have continued refinement, and have developed the inevitable jargon to go with it. In 1973 Muller-Merbach laid out a framework of the various approaches used by the industrial sector.[26]

Since program planning (PP) is a simplified form of linear programming (LP), many of the terms used in LP can be used to describe PP operations. PP can be divided into two stages, obtaining a first feasible solution (FFS), and iteratively improving solutions (IIS).[27] The FFS stage simply finds a solution in which the constraining conditions are met. This is a necessary step before proceeding to find improved soltuons. IIS involves performing a sequence of iterations in the feasible range, until no further improvement to the gross margin (GM) can be made. This is exactly the procedure followed in LP. The difference is that in LP there is a predetermined procedure to follow in deciding which resource to add in the next iteration. In PP there is no set rule for this.

Two general approaches have been used in ISS. The first, defined as "Eager but Tedious" (EBT) simply solves the problem at all solution points without attempting to always search for an improved solution. If some thought is applied, many of the possible solutions can be bypassed on the road to an optional or near-optional solution. This has been referred to as "Reflective and Skilful Seeking" (RSS).

In a review of the PP methods used in agricultural settings, a variety of methods, and mixes of methods appeared based on Muller-Merbachs' definitions. Clark presented FFS solutions which he considered of limited use.[28] Weathers in his first example used an IIS-EBT method with three sets of side tables as the basis for making choices from his rules.[29] In his following examples the method might be described as IIS-EBT-RSS. The rules were still there but a little reflection showed a way to cut the amount of work. Rickards and McConnel start off with a IIS-EBT method but, having found an optimum solution, deteriorate it and switch to an IIS-RSS method.[30] Johnsson, Rembourg and Safvestad lay out a specific set of seven rules that must be followed,[31] thus identifying their method as IIS-EBT. One of the reasons for this is the method was used throughout Sweden in the early 1960's, and it was assumed the extension workers needed a set of rules to follow. Of all the models found, this was the one most likely to give consistent solutions but how near the solutions would be to optimum is unknown. A Norwegian version was brought out two years after the Swedish method but it had a major difference.[32] It suggested judgment be used in the selection of the enterprises, and trial-and-error methods be used in the combination of enterprises.[33] Clark gives an abstract of the methods used in the working sheets.[34]

Two other methods, which could be considered falling in the general area of program planning, developed by the Max Planch Institute, are slide rule and a graph method. The Bleckstein Slide Rule has seven scales for various ratios basic to most German farms.[35] The farmer's resources are used as a basis and various combinations can be worked out using the standards assumed in the scales on the slide rule. This is an IIS-EBT method. Cropping Systems Research is in need of something with more flexibility. The geometric planning method is limited to three enterprises and has had little use because of this limited range. The method is also IIS-EBT. McFarquhar works through a three enterprise system.[36]

Although the assumptions of specific relationships given by Muller-Merbach do not seem to be totally valid for the work found in Agricultural Economics, the approach and definitions are clearly a help in understanding and comparing PP methods.

Considering the research philosophy, objectives and operational procedures of cropping systems research, the IIS-RSS-RPD approach seems the most appropriate. The emphasis is on site-specific research, so the economist at the site will be responsible for most of the economic decisions to be made in the planning phase. He will be in a rush and will not likely have time to work through an EBT approach with a set of given rules. In fact, a given set of rules from headquarters would probably result in poorer solutions, since they would overrule the informal knowledge he has gained. By using the RSS approach advantage can be taken of this subjective knowledge by utilizing it in a formal procedure. This approach will also allow him to explore possible new technologies before they are tried on the farm. However, as with any new tool it will take practice to become skilful in its use. It should also be remembered that it is not likely to give the most efficient solution, rather it is likely to give a set of possible solutions.

By the time the PP stage of the analysis is reached, there should be a very small number of alternative enterprises to consider, and a limited number of constraints. The smaller these can be kept, the easier and quicker a solution can be found. The data required is laid out in a table showing the production process, resource constraints under consideration, resources required for each unit of output from the production process, and limits on the production process--either minimum or maximum.

A hypothetical example of program planning. Table IV-4, part A shows the initial layout of a hypothetical case. There are twenty hectares available on which additional rice, maize, mung bean or tomatoes can be grown as shown in Column 1. Column 2 shows gross margin which is gross return minus variable costs. Column 3 is the land required for each crop plus total available at the bottom. The cash cost of growing one hectare of each crop plus the total cash available is shown in Column 4. Column 5 shows the labour required per hectare, to grow each crop in week thirty, with a total of 400 hours available. Column 6 is the same labour data for week forty-four. Buffalo days per hectare, per crop is given in Column 7. On the far righthand side is the maximum area that each crop can have. These are established either by setting a limit, such as one hectare of tomatoes, or by dividing each number in the row into the total available resource in its column and taking the smallest number. For additional rice 1,500/50 = 30, 400/5 = 120, 600/10 = 60 and 40/4 = 10, so power in the 28th week limits additional rice area to ten hectare.

TABLE IV-4

PROGRAM PLANNING EXAMPLE

Production Process	Gross Profit ($/ha)	Land (ha)	Cash Cost ($/ha)	Labor 30-week (hr/ha)	Labor 44-week (hr/ha)	Power 28-week buffalo/ha	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
PART A							
Additional rice	100	1	50	5	10	4	10 ha power
Mung bean	50	1	10	10	50	1	12 ha Lab. 44 week
Maize	150	1	100	10	40	2	15 ha Lab.& cash 44 week
Tomato	300	1	300	60	10	1	1 ha veg
Available resources		20	1,500	400	600	40	
PART B							
Tomato	300	1	300	60	10	1	
Maize	1,800	12	1,200	120	480	24	
Resources	2,100	13	1,500	180	490	25	
PART C							
Tomato	300	1	300	60	10	1	
Maize	1,500	10	1,000	100	400	20	
Rice	400	4	200	20	40	16	
Resources	2,200	15	1,500	180	450	37	
PART D							
Tomato	300	1	300	60	10	1	
Maize	1,500	10	1,000	100	400	20	
Rice	300	3	150	15	30	12	
Mung bean	150	3	30	30	150	3	
Resources	2,250	17	1,480	205	590	39	

The next step is to put the crop with the highest gross profit in part B, in this case tomatoes. Since it is limited to one hectare, the gross profit is 300 and each of the other rates is written in for one hectare. Since there are still resources left, find the crop with the next highest net profit, maize, and write it in Column 1. To decide how many hectares to plant, check the righthand column to find which resource was limiting, in this case, labour in the 44th week, and cash. Since tomatoes used little of that labour, it is likely cash will be limiting. Tomatoes used $300 cash so there is $1,200 left and maize takes $100 per hectare so twelve hectares can be planted. Now the maize row can be filled in multiplying each number in part A for maize by twelve. Gross margin equals 150 x 12 = $1,800, land 1 x 12 = 12, cash cost 100 x 12 = $1,200, labour in week 30, 10 x 12 = $120, and so on. Since all the cash is used up and no process requires zero cash, stop. Add each column. The gross margin is $2,100 but only thirteen hectares of land have been used, 180 hours of labour in week thirty, 490 in week forty-four, and the buffalo only worked twenty-five. Cash is the limiting resource in this solution. Now the solution is deteriorated and another try made. A hectare of rice takes only half the cash that maize does, $50 versus $100 in column 4. Checking the rice row in part A, the limiting factor is power. If three hectares of maize are dropped, leaving nine, an additional six hectares of rice can be grown considering the two to one ratio in cash. Checking the power requirement, tomato 1 x 1 = 1, maize 9 x 2 = 18, and rice 6 x 4 = 24, gives 1 + 18 + 24 = 43, but only 40 available, so try ten hectares of maize and four hectares of rice. The gross margin increased by 100. No more rice can be added due to the power constraint. Now deteriorate part C and try again. Mung bean used little cash or power. Its constraint is labour in the 44th week. There are 600 - 450 = 150 hours unused, Column 6. Adding three hectares of mung bean would increase gross margin $150 which just equals one hectare of maize. One hectare of rice will be removed to get cash to grow the mung bean, part D. Gross margin has increased by $50. The constraint is labour in the 44th week. If more labour were available, there are sufficient other resources to grow one more hectare of mung bean. The farmer would have to hire an additional forty hours of labour to harvest mung bean for an additional gross margin of $50. If labor is worth less than 50/40 = $1.25/hour it will pay him to do so. The $1.25/hour is known as a shadow price.

As is clear from the above example, program planning does not have a strict set of rules to follow in its use. Guesses or estimates have to be made. However, with a small amount of practice the economist soon develops the ability to run his eye over the rows and pick out opportunities to increase the profit. With a little experience, program planning can be a very useful tool. It uses judgment, plus systematic procedures.

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CHAPTER V

SITE DESCRIPTION AND DATA COLLECTION

The Sites

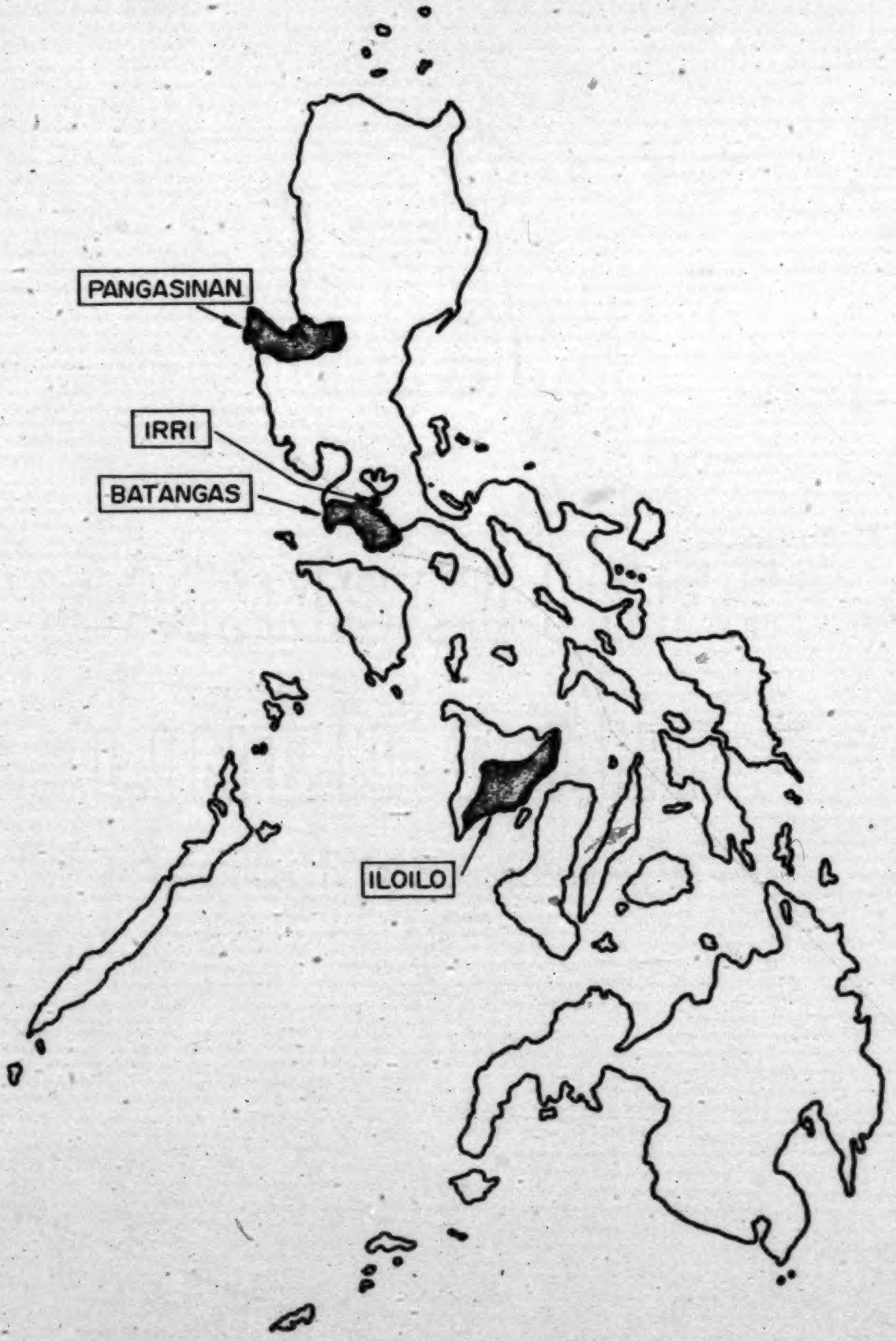
Three sites will be considered in this study, all located in the Philippines. They are: Batangas in the southwest corner of Luzon Island, Iloilo on a small island in the centre of the Philippine chain of islands, and Pangasinan in the west-central part of Luzon Island. (Figure V-1) These are the first three sites where IRRI conducted cropping systems research. These sites were selected for this study since each has a fairly complete set of data, and the research staff that worked at the sites were in IRRI and so could be consulted if problems regarding the data arose. The Batangas site was also selected because of its proximity to IRRI and the complexity and productivity of its cropping systems. The other two sites were chosen on the basis of agro-climatic environment and because it was thought that new technology was available which could increase the productivity of the areas.

Batangas

Batangas Province lies sixty kilometres south of Manila in the southwest corner of Luzon. The village of Cale in the Municipality of Tanauan was selected for the research site. It is located about twenty-eight kilometres from IRRI and seven kilometres from the municipal

FIGURE V-1

CROPPING SYSTEM RESEARCH SITES IN THE PHILIPPINES


PANGASINAN
IRRI
BATANGAS
ILOILO

capital, in the northeast corner of the province.

Land

The latest agricultural census of Tanauan shows 5,574 hectares suitable for cultivation of which 5,480 were planted in 1971.[1] At that time there were 3,856 farms in the municipality with a mean area of 1.45 hectares arable land. There were also 2,099 hectares of permanent crops giving an average of over one half hectare of tree crops per farm.[2] Twenty-three percent of the farms are less than one hectare, 58 percent one to three hectares, 15 percent three to five hectares and 4 percent over five hectares. The soils at Cale are of recent volcanic origin. Taal Volcano, only eight kilometres west of the site, last erupted in 1976, spreading another thin layer of volcanic ash on the area. The soil has a pH of 5.4, organic matter of 1.7 percent, available phosphorous of 38 ppm, available potassium of 248 ppm and is in the clay/silt/loam category. A special characteristic of the soil is that it can be ploughed when wet and not lose its structure. For sequential planting of upland crops this is a very valuable characteristic. The topography is rolling to gently rolling. The landscape is dotted with a variety of trees, and in the village each house has many fruit trees. The area has five consecutive months with over 200 mm of rain from June to October and five consecutive months with less than 100 mm from December to April. The water table is about three metres and there is no irrigation.

Population

The population of Tanaun has been growing rapidly and now stands at 600-799 people per square kilometre.[3] In 1903, there were 18,263 people:

in 1948, 30,203; in 1960, 44,975. The population reached 61,910 in 1970 and increased a further 4,793 by 1975 giving a compounded annual increase of 1.5 percent.[4] The municipality is losing its young men, as there are 8.6 percent fewer men than women in the twenty to forty-nine age group. (Table V-1)

TABLE V-1

POPULATION OF TANAUAN BY AGE AND SEX[5]

Age Group		Male	Female
20-24		3,170	3,289
20-29		2,270	2,474
30-34		1,733	1,932
35-39		1,536	1,716
40-44		1,323	1,525
44-49		1,158	1,218
	TOTAL	11,190	12,154

Since there is such good communication with Manila many of the young men go there for employment. Farmers and farm workers make up 94 percent of the census category of Farmer, Fisherman, Hunter, Logger, and Related Workers, in Batangas. In this category 35 percent have three years or less eduction, 55 percent have four to seven years of education, 9 percent have attended high school and 1 percent have some college education.[6] There is little difference between the males' and females' education in this category. This category constitutes 48 percent of the gainfully employed, so Batangas is considered a rural province.[7] In Batangas there are 79,053 farmers and farm managers, 26,340 paid farm workers, and 28,216 unpaid family farm workers.[8] The village of Cale had 985 males and 1,025 females in 330 households in 1975; thus, the average household size was 6.1.[9]

Land tenure is an important consideration throughout the Philippines. In Batangas the tenure situation is changing. The number of tenants is decreasing and full owners increasing. (Table V-2)

TABLE V-2

LAND TENURE IN BATANGAS[10]

Tenure Position	Number of Farmers (Percent) 1960	Number of Farmers (Percent) 1971	Land Area (Percent) 1960	Land Area (Percent) 1971
Tenant	55.3	42.2	50.3	39.1
Full owner	26.8	44.5	27.0	39.2
Part owner	17.5	12.8	20.7	13.7
Manager	0.1	0.1	1.8	7.5
Other	0.4	0.4	0.2	0.5

The population pressure on the land is increasing. In 1960 the average full owner farmed one hectare, while in 1971, it had dropped to .88 hectares. The part owner's average farm also fell from 1.18 to 1.07 hectares. The large land owners appear to increase their holdings as the average manager's farm size increased from eighteen to seventy-five hectares and the number remained the same. This is probably due to sugar cane which is the most important crop in Batangas.[11] Rice is the second most important crop in terms of value of production. Rice is the main crop for 46 percent of the farmers, while sugar cane is the main crop of 16 percent. (Table V-3) The average rice farm size by tenure shows there is little difference according to tenure except for the "Other tenant" category, which includes only 2 percent of the rice farmers.

There is a major difference in sugar cane holdings with "Others", which consists mainly of managed farms, being ten times larger than all other tenant categories.

TABLE V-3

RELATIONSHIP OF FARM CLASSIFICATION AND LAND TENURE IN BATANGAS[12]

Major Crop	Full Owner	Part Owner	Share Tenant	Other Tenant	Others	Total Farmers
			Number of Farms (Percent)			
Rice	44	15	39	2		26,979
Sugar cane	18	8	70	2		9,565
Others	56	12	28	2	2	21,596
			Land Area (Percent)			
Rice	42	17	39	1	1	49,550
Sugar cane	16	8	48	2	26	38,486
Others	54	15	28	2	1	49,810
			Mean Farm Size (ha)			
Rice	1.75	2.08	1.84	.92		2.01
Sugar cane	3.6	4.02	2.76	4.0		52.4

There are many share arrangements in Batangas but 40 percent are under a fifty/fifty arrangement, 21 percent under thirty/seventy, 14 percent under thirty-three/sixty-seven, while the rest are under a variety of special arrangements.[13] However, what is not stated in the census report is what sharing arrangements is made on the cost of fertilizer.

Fragmentation does not appear to be a serious problem at this time (Table V-4). The majority of farmers have two or three parcels of land but these often have different characteristics and so can spread the work out as different cropping patterms are grown on each.

In addition, many of the farmers have tree crops on a small parcel.

TABLE V-4

FRAGMENTATION AND AREAS OF FARMS IN TANAUAN[14]

Parcels	Number	Area (ha)	Mean Farm Area (ha)
1	764	857	1.12
2-3	2,406	4,249	1.77
4-5	562	1,634	2.91
5 plus	124	557	4.49

The farmers in Batangas are famous for the variety of crops they grow and have earned a reputation as good farmers throughout the Philippines. Because of their constant interaction with markets in Manila they are very responsive to price changes for their cash crops.[15]

Iloilo

The province of Iloilo is located on the island of Panay in the Western Visayas. It is located on the south side of the island with Iloilo City, its capital, being its major port. The research site falls in two municipalities--Oton and Tigbauan. The site is about twenty kilometres from the capital. The total IRRI study area covered nine villages, but this study will only consider five of them: Napnapan Norte, Cordova Norte, and Cordova Sur in Tigbauan; and Rizal and Sta. Monica in Oton. These five were selected because linear programming models have been run on farms in these villages.

Land

The municipalities of Oton and Tigbauan have 7,717 arable hectares of which 7,555 were planted in 1971. This land was operated by 4,149 farmers giving an average of 1.86 hectares of arable land per farm.[16] Farms of less than one hectare represented one-fifth of all the farms in the two municipalities. Over 57 percent of the farms were one to three hectares, 16 percent were three to five hectares, and 7 percent were over five hectares.[17] The soils on the study site are relatively homogeneous. An analysis of seventy fields showed an average pH of 5.8, organic matter 2.07 percent, available phosphorous 27 ppm, 218 ppm exchangeable potassium, and a textural class predominantly clay/loam.[18] There was a major difference in topography. The plots in Tigbauan were plateau or bottomland, while Oton's topography included plateau, bottomland, side-slope, and upland.[19]

The rainfall pattern is five to six consecutive months of over 200 mm per month from May to October, and two to four months with less than 100 mm per month in the period January to April.

Population

The population of Oton and Tigbauan municipalities is growing rapidly. There was a population of 25,412 in 1903, increasing to 50,050 in 1960 and 60,258 in 1970. From 1970 to 1975 the population increased by 7,030 people giving a compounded annual increase of 2.23 percent.[20] This appears to be the natural growth rate of the population, indicating the people are remaining in the municipalities. The data in Table V-5 shows that conditions may have recently changed, since the older age groups have a majority of women. The young men are staying in the municipalities to work.

In Iloilo, the census group of Farmer, Fisherman, Hunter, Logger and Related Worker had the following levels of education: three years or less, 31 percent; four to seven years, 55 percent; high school, 12 percent; and college, 2 percent. The percentages for male and female were the same.[21]

TABLE V-5

POPULATION OF OTON AND TIGBAUAN
BY AGE AND SEX IN 1975 [22]

Age Group	Male	Female
20-24	2,787	2,624
25-29	2,008	2,195
30-34	1,852	1,928
35-39	1,728	1,906
40-44	1,434	1,578
45-49	1,319	1,351
TOTAL	11,128	11,582

The population density in the two municipalities is approximately 500 per km^2 or 2,000 m^2 per person.[23]

Agricultural industry workers make up 57 percent of the population of Iloilo.[24] This classification breaks down into 84,487 farmers, 84,929 paid workers, and 44,045 unpaid family workers. Each farmer averages half a family member's time and one paid worker.[25]

Assuming that the female population is stable, the men in the five villages have been staying in the village and others have been coming to work. (Table V-6) This is usually an indication that the level of economic activity in an area is high. Since these villages have only agriculture it appears it is profitable.

Two other characteristics which help describe a site are land tenure and the crops grown. Land reform appears to be having an impact in Iloilo but the tenants are clearly working with smaller

TABLE V-6

POPULATION AND HOUSEHOLDS OF THE FIVE SELECTED VILLAGES IN ILOILO, 1975[26]

Village	Male	Female	Total	Households	People/ Household
Rizal	466	431	897	162	5.5
Sta. Monica	813	780	1,593	281	5.7
Cordova Norte	485	444	929	176	5.3
Cordova Sur	369	345	714	112	6.4
Napnapan Norte	461	453	914	153	6.0
TOTAL	2,594	2,453	5,047	884	5.7

land holdings than the other tenure groups. (Table V-7)

TABLE V-7

LAND TENURE IN ILOILO[27]

Tenure Position	Number of Farmers (Percent) 1960	Number of Farmers (Percent) 1971	Land Area (Percent) 1960	Land Area (Percent) 1971
Tenant	56	42	43	31
Full owner	30	43	36	49
Part owner	12	13	15	15
Other	2	2	6	5

Rice is the most important crop in Iloilo, as 76 percent of the farmers had rice as their main crop; however, their farms made up only 62 percent of the area in crops. (Table V-8) The average rice farm size by tenure group showed share tenants the smallest with 2.1 hectares, then other tenants with 2.8 hectares, full owners with three hectares, part owners with 3.4 hectares, and others with 4.1. Assuming the share tenant gives one-third of the crop to the landlord after the harvesters' one-sixth is taken out, the tenant has an effective area of 1.3 hectares to produce the rice he needs. Sugar cane is the other major crop grown on the island, which explains why under "Other" forms of land tenure, only 1 percent have 9 percent of the land.

TABLE V-8

RELATIONSHIP OF FARM CLASSIFICATION AND LAND TENURE IN ILOILO IN 1971[28]

Major Crop	Full Owner	Part Owner	Share Tenant	Other Tenant	Others	Total Farmers
		Number of Farms (Percent)				
Rice	37	13	42	6	2	57,348
Others	60	13	22	4	1	18,116
		Land Area (Percent)				
Rice	42	16	33	6	3	153,820
Others	60	15	11	5	9	94,546

Fragmentation of land holdings can have an effect on the crops grown and the management they receive. In the two municipalities under consideration, 54 percent of the farmers had one parcel with an average farm size of 1.7 hectares. The farmers with two or three parcels made up 40 percent of the total and had 2.3 hectares, while 6 percent had four or more parcels and 4.4 hectares.[29]

Pangasinan

The province of Pangasinan is located approximately 200 kilometres north of Manila and 100 kilometres south of Baguio. The province is in the northwest corner of the central plains area of Luzon Island. The research site is in the Municipality of Manaoag, which lies slightly north of the centre of the province. Within the municipality five villages were selected for research, Anis, Lipit Sur, Lipit Norte, Pao and Caaringayan.

Land

The last agricultural census was done in 1971, but it still gives an idea of the general land situation in Manaoag.[30] There are 3,947 hectares suitable for cultivation of which 3,716 were planted in 1971. There were a total of 2,724 farms with a mean area of arable land of 1.45 hectares.[31] The farms can be divided into four groups based on total farm area: 28 percent under one hectare; 59 percent, one to three hectares; 11 percent, three to five hectares; and, 2 percent, over five hectares.[32] The soils in all five villages are relatively homogeneous. They fall in the San Manuel series and the Eutropept Great Groups of Soils.[33] [34] The soil surface texture is calcareous clay loam with a mean pH of 7.4, organic matter of 2.1 percent, 128 ppm available phosphorous and 237 ppm exchangeable potassium. Iron availability is low under aerobic conditions and zinc availability is low under anaerobic conditions due to the high pH.[35] The topography is nearly level plain. On the average there are six consecutive dry months with less than 100 mm of rain and four consecutive months with over 200 mm of rain. The average rainfall is 1,980 mm per year.[36] There are two distinct water tables in the area. Lipit Sur, Lipit Norte and Pao have a deep water table, while Caaringayan and Anis have a shallow water table with several artesian wells in the area.[37]

Population

The population of Manaoag has grown rapidly and now is levelling off at between 600 and 899 people /km^2.[38] In 1903 there were 16,793 people and in 1960, 41,164. By 1970, the population had reached 48,091 but in the next five years it only increased by 359 people giving a compounded annual increase of 0.15 percent.[39] Such a low population increase indicates people are leaving the municipality. There is clear evidence of this in Table V-9.

TABLE V-9

POPULATION OF MANAOAG BY AGE AND SEX IN 1975[40]

Age Group	Male	Female
20-24	1,987	2,106
25-29	1,579	1,655
30-34	1,271	1,366
35-39	1,153	1,201
40-44	931	1,044
45-49	839	915
TOTAL	7,760	8,287

In the age groups when people are most productive there are 6 percent fewer men than women in Manaoag. It is assumed that these men have left to find work in other areas. The census data combines farmers, fishermen, hunters, loggers, and related workers in the data dealing with education but since 92 percent of the people in Pangasinan in this group are farmers or farm workers, it is assumed to be a fairly accurate indication of the farmers' and farm workers' educational level.[41] Over 25 percent have three or less years' education; about

54 percent have four to seven years of education; 18 percent have attended high school; and over two percent have attended college.[42] The data shows that there is an equal percentage of males and females at each educational level.

Pangasinan is a rural province since 54 percent of the gainfully employed are in agriculture, hunting, fishing, or logging industries.[43] In agriculture this breaks down into 132,781 farmers, 13,615 paid agricultural workers, and 44,345 unpaid family workers for Pangasinan.[44] The population of the five villages selected shows again that the men have been leaving the villages. (Table V-10)

TABLE V-10

POPULATION AND HOUSEHOLDS OF THE FIVE SELECTED VILLAGES IN PANGASINAN, 1975[45]

Village	Male	Female	Total	Households	People/ Household
Anis	248	248	496	96	5.2
Lipit Sur	595	604	1,199	204	5.9
Lipit Norte	440	442	882	147	6.0
Pao	882	919	1,801	309	5.8
Caaringayan	486	452	938	186	5.0
TOTAL	2,651	2,665	5,316	942	5.6

Two other characteristics that are important in any agricultural community are land tenure and the crops grown. The land tenure situation in Pangasinan is changing. The proportion of tenants is dropping and full owners increasing (Table V-11).

TABLE V-11

LAND TENURE IN PANGASINAN[46]

Tenure Position	Number of Farmers (Percent) 1960	Number of Farmers (Percent) 1971	Land Area (Percent) 1960	Land Area (Percent) 1971
Tenant	50	40	43	35
Full owner	27	35	28	34
Part owner	22	22	26	27
Other	1	3	3	4

The land reform program of the Government of The Philippines appears to be having an effect in Pangasinan. Rice is the most important crop in Pangasinan. Over 85 percent of the farmers' main crop was rice and their farms made up 83 percent of the area in crops (Table V-12). The average rice farm size by tenure shows that the share tenants had 1.6 hectares, full owner 1.8 hectares, other tenants and others 2.1 hectares and the part owners 2.3 hectares. Considering that the share tenant usually gives one-third of the crop to the landlord after the harvesters' one-sixth is taken out, the share tenant has to produce his rice on an effective area of about one hectare.

Fragmentation of holdings is usually a consideration in Asian farms. In Manaoag fragmentation is a function of size. The 27 percent of the farmers who have only one parcel have an average farm size of one hectare. The 52 percent with two or three parcels have 1.6 hectares, while the 19 percent with four or five parcels have 2.5 hectares. Those with six or more parcels have 3.2 hectares.[47]

TABLE V-12

RELATIONSHIP OF FARM CLASSIFICATION AND LAND TENURE IN PANGASINAN, 1971[4]

Major Crop	Full Owner	Part Owner	Share Tenant	Other Tenant	Others	Total Farmers
			Number of Farms (Percent)			
Rice	34	22	34	6	4	76,455
Others	42	23	27	4	4	12,850
			Land Area (Percent)			
Rice	32	27	30	7	4	143,916
Others	42	28	21	3	6	29,408

Data Collection

Batangas

Baseline Survey

In April of 1973, a baseline survey of 100 farmers in Cale was conducted. The survey took two to three hours per farmer. In addition to resources and cropping pattern information, data was gathered on the last season's costs and returns by crop.

The survey showed that the average farm had 6.4 in the household, 0.93 hectares, and 22.5 months of family labour available per year. One-half of the farmers owned no land, and one-half had no off-farm income.[49] About one-half were share tenants while 32 percent were part owners, and 20 percent full owners. The most common cropping pattern was rice followed by corn. However, 53 percent of the farmers also grew some vegetables in both the first and second season. Six percent of these grew only vegetables, mainly on trellises. The farmers were growing traditional varieties of rice, corn, and most vegetables, but were using relatively high rates of fertilizer, and had all used insecticides. Hired labour was only used for harvesting rice by most farmers.

Generally, the baseline data showed the farmers in Cale were typical of Tanauan Municipality, but they grew more vegetables than typical of Batangas, and so had a higher return per farm and per hectare.

In addition to the baseline survey, a social survey was conducted in Batangas in 1974. This survey covered 248 farmers and included seventy farmers and their wives from Cale.[50]

Record-Keeping

Since Cale was located within one hour's drive of IRRI, no office was established there until the agronomists needed one in 1975. The farm record-keeping was handled by one IRRI research assistant with the aid of a village assistant. All records were returned to IRRI for summary, checking, and analysis. IRRI staff visited the site often due to its easy access.

In the baseline survey ninety-two of the 100 farmers stated they would be willing to keep farm records. Fifty farmers were selected on the basis of their cropping pattern, resource base, and apparent management ability. The farmers were given one form to fill out. They were asked to list each activity that related to crops. The village assistant and the IRRI research assistant checked the forms at least once a week and in the busy seasons, twice a week. In the second year, the farmers were also asked to record all income and expenditures for the family, livestock as well as crops. This was stopped after the third year as it required a lot of work on the part of the farmers and could not be analyzed by the team at IRRI. In the third year, three new forms were introduced, which made coding for computer input much easier. The first form kept track of livestock inventory. The second form recorded all crop-related activities and the resources used in those activities. There were about eighty catgories in this form. The third form with thirty categories was to record all income and expenditures for the farm and the households. Another village assistant was hired to assist in record-keeping. The record-keeping was continued until the end of the 1976-77 crop year.

In addition to the farm record-keeping, data was collected on a variety of agronomy trials, and cost and return analyses run where applicable. Basic data on cropping patterns and data for special studies are still being collected in the 1979-80 crop year.

Iloilo

Baseline survey

The survey was conducted in early 1975, by the staff of the Economic Department of IRRI and covered 241 farmers in the municipalities of Oton and Tigbauan. The survey obtained an average of 550 answers per farmer and took an average of two hours per interview. The survey was completed in January 1976, and to-date has not been fully analyzed. The survey questions asked about land holdings, crops grown, inputs used on the crops, yields, labour availability, power used, income from crops, livestock, and other sources.

The baseline survey found the average farm size to be 1.45 hectares, with most farms having two parcels and no irrigation. Share tenancy was the most common land tenure form, with full owner second. About 80 percent of the land was in crop in June which was the highest land utilization month. The most common cropping pattern was a single crop of rice in one year. This pattern accounted for 82 percent of the cropland. Rice followed by an upland crop accounted for 13 percent, with a rice-rice pattern accounting for 5 percent of the cropland. The multiple cropping index in the 1975-76 crop year was 148. Over 90 percent of the farmers were growing some modern varieties but were using low levels of inputs. The average rice yield was 1.8 tonnes per hectare. Hired labour accounted for 50 percent of the labour and was used mainly for transplanting and harvesting. Most of the land preparation was done by the farmer or his family with a cow or water buffalo they owned. About 40 percent of the farmers used credit mainly from government banking institutions and private money-lenders. The farmers surveyed owned 100 cows and water buffalo, fifty pigs and 1,400 chickens. Livestock and off-farm income made up a very small part of the total income. Crop production accounted for 85 percent of the total farm income.[51]

Generally, these finding coincide with the data from the census. Thus, it can be assumed that these were representative villages of the area at the time the selection was made.

Record-Keeping

An office for the research site was set up in the village of Oton in early 1975. Five IRRI researchers were assigned to the site. In addition, five people were hired to work in the office and eleven village assistants were hired, from the villages to be studied. Senior staff from IRRI visited the site on the average of once every two weeks and most experiments and methodologies were worked out in consultation with them.

During the baseline survey one of the questions asked was if the farmer would be willing to be an economic co-operator. It was explained that an economic co-operator would be required to keep records of his activities with the help of the village assistant. A total of eighty agreed. A random selection of forty-five economic co-operators was made. These economic co-operators were given three sets of forms to record daily activities. These forms were the same as those described for Batangas. Although specific daily activities would not be used in the analysis, it was assumed that more accurate data would be obtained if the farmer recorded daily. These forms were collected once a week by the village assistant. In addition, he checked the forms halfway through the week, to ensure they were complete and accurate. The village assistant had a definite schedule so the farmer knew when he would be coming. The data was taken to the site office, rechecked, and summarized on a weekly basis. This data was then used in calculating costs and returns, returns to factors of production, and flow of cash and labour. This procedure was carried on for the crop years 1975/76 to 1977/78.

At the same time, a group of fifty-nine agronomic co-operators were chosen, nine of whom overlapped with the economic co-operators. These agronomic co-operators agreed to carry out an experiment in one of their fields of at leat 500 m^2. The results of these experiments formed the foundation of the new technology.

Pangasinan

Baseline Survey

The survey was done in the months of February to April of 1975 by staff from the Economics Department of IRRI. The survey covered 185 farmers, picked at random from the Municipality of Manaoag. The questionnaire used was the same as the one used at the Iloilo site. The survey has not been completely analyzed. One thesis has been finished using some of the data but only 56 percent of the questionnaires were analyzed since the mass of data was too great.[52] The researcher felt little additional precision would be gained from analyzing the remaining eighty-two farmers' data.[53]

The survey indicated that the farmers had an average of 1.6 hectares divided into three parcels. Lowland rice area accounted for 75 percent of cropland while the rest was upland. The average household had six family members. Labour use for all crop production per farm was: operator, thirty days; family sixteen days; exchange, seven days; and hired labour, fifty-five days, for a total of 105 days. Rice production used 70 percent of this labour. Share tenancy was the dominant land tenure, accounting for 53 percent of the farmers. Part owners were next with 24 percent, while full owners constituted only 8 percent. The remaining 15 percent were a wide variety of tenure arrangements. The farmers planted 84 percent of their land to rice, 46 percent to mung bean, and 14 percent to sugar cane. Their over-all Multiple Cropping Index was 160. The major cropping pattern was rice-mung bean covering 54 percent of the crop area. Rice-fallow was next, covering 10 percent, sugar cane 9 percent and rice-mungbean-corn 8 percent of the cropland. A total of twenty-eight different patterns were grown by farmers, with most growing only two, but a few had ten patterns on their farm. The over-all management level on the rice crop is average for the Philippines. Modern varieties were planted on 56 percent of the rice-cropped area. Pesticides and fertilizer were used by nearly all the farmers with an average of 110 kg fertilizer per hectare applied. Credit was used by 83 percent of the farmers, with institutional credit accounting for

87 percent of the loans. Rice accounted for 46 percent of their gross income; other crops, 24 percent; livestock, 12 percent and non-farm sources, 18 percent, based on an average gross income per farmer of 6,026 pesos. Net farm earnings showed a significant change in relative importance of sources. Total net farm earnings were 3,255 with non-farm sources accounting for 32 percent and farm sources for 68 percent.[54] This relatively high non-farm income is coming from the young men who have left the area as reflected in the census data.

Record-Keeping

A site office was started in April 1975. A senior research assistant from IRRI was assigned as research site co-ordinator, plus an economic and biological team leader. The Bureau of Plant Industry assigned two technicians to the site. To support this staff, ten village assistants were hired, plus four labourers. There was a full staff of twenty-four people working at the site. In addition, IRRI staff visited the site on the average of once a week, to assist in the planning and execution of the research.

Following the baseline survey and establishment of an office, fifty economic co-operators were selected from among those farmers who had expressed a willingness to act in that capacity, using the following criteria; willingness to keep records, be a full-time farmer, have a farm between 0.5 and 5 hectares, and someone in the household who can read and write. The selected farmers were given the same three sets of forms described for the Iloilo site. The village assistants visited each farmer twice a week, on a regular basis, and collected the forms on the second visit. The data was handled in the same manner as described for Iloilo.

A total of fifty-four agronomic co-operators were chosen at the same time as the economic co-operators. There were twenty-four co-operators who were in both groups. The agronomic co-operators agreed to carry out two trials on their farm. The trial plots ranged in size from 500 to 1,500 m^2. All activities on the trial plots were recorded separately. The project supplied the material inputs, while the farmer supplied the land, labour, power, and management. However, any new procedure was fully discussed with the farmer to ensure a workable methodology was suggested. The farmer got all the product from the trial plot, but if the crop failed, he got nothing.[55]

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CHAPTER VI

ANALYSIS AND RESULTS

Data from the IRRI cropping systems research site at Cale, Batangas in the Philippines will be used to develop and pretest the informal procedure. Then using cropping systems sites data from Iloilo and Pangasinan the informal and LP solutions will be compared. To ensure that the informal procedure is giving results comparable to the traditional method, comparisons will be made at each step of the analysis. Since large amounts of data are a problem at the ACSN sites, the informal procedure will be compared with traditional procedures on thirty-six farms and on five case study farms. The objective of this chapter is not to supply a detailed study of the sites, but to compare the results from the different procedures. The conclusions resulting from both procedures, regarding areas needing further research and the acceptability of a new technology, will also be compared.

The Cale Site

Descriptive Analysis of Farming System

The three major crops grown in Cale are rice, maize, and vegetables. During the four-year period under study, 1973-1977, the proportion of the crops did not change substantially on the thirty-six study farms (Table VI-1). The area cropped and farmed decreased as older farmers gave up some of their rented land, when sons started to

TABLE VI-1

AREA PLANTED TO CROPS ON THIRTY-SIX FARMS IN CALE, 1973-77

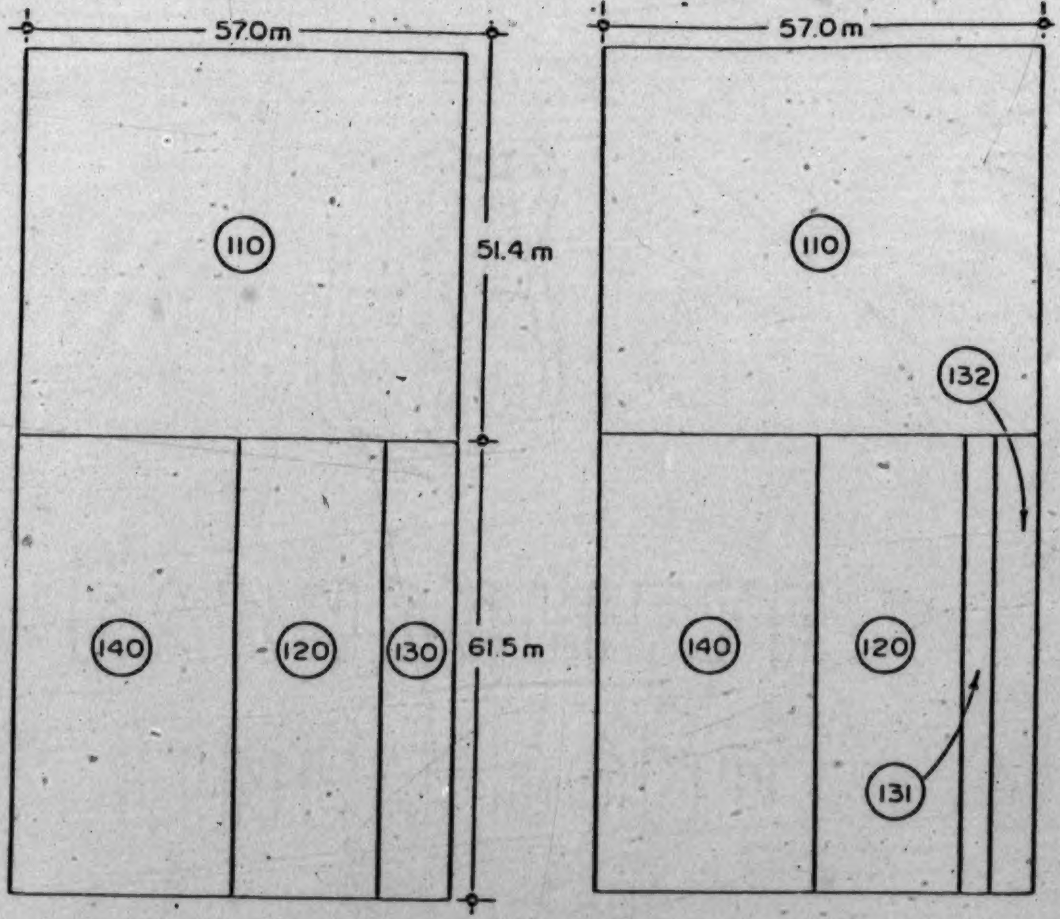
	Years			
	1973-74	1974-75	1975-76	1976-77
Rice (percent)	39	43	38	38
Maize (percent)	35	33	30	35
Vegetables (percent)	26	24	32	27
Cropped Area (ha)	72	66	58	60
Farm Crop Area (ha)	45	44	42	40
Multiple Cropping Index	160	150	138	150
Mean Cropped Area/Farm (ha)	2	1.8	1.6	1.7

farm on their own. The period under study had a relatively stable crop production background. However, these aggregate figures hide a very complicated cropping system. Figures VI-1 to VI-4 show the crops grown and the crop arrangment on one parcel of land over four years. In each year a sequence of two crops was grown, giving eight crop periods. The farmer owning this parcel also has three other parcels where a variety of crops are grown.

The decision to change the direction of rows from 1976-77 meant it was impossible to study the effect of previous crops and management inputs as there would be seventy-two interactions in one part of the field. In addition to this problem there are a number of very narrow strips, some only one metre wide, containing different crops. It is very difficult to get reliable data from such small plots and, yet, if a farmer has many of these they cannot be ignored. To solve the

FIGURE VI-1

CROPS ON PARCEL 25-1 IN CALE,
TANAUAN, BATANGAS, 1973-74


57.0m
110
51.4 m
140
120
130
61.5 m
57.0m
110
132
140
120
131

FIRST CROPS

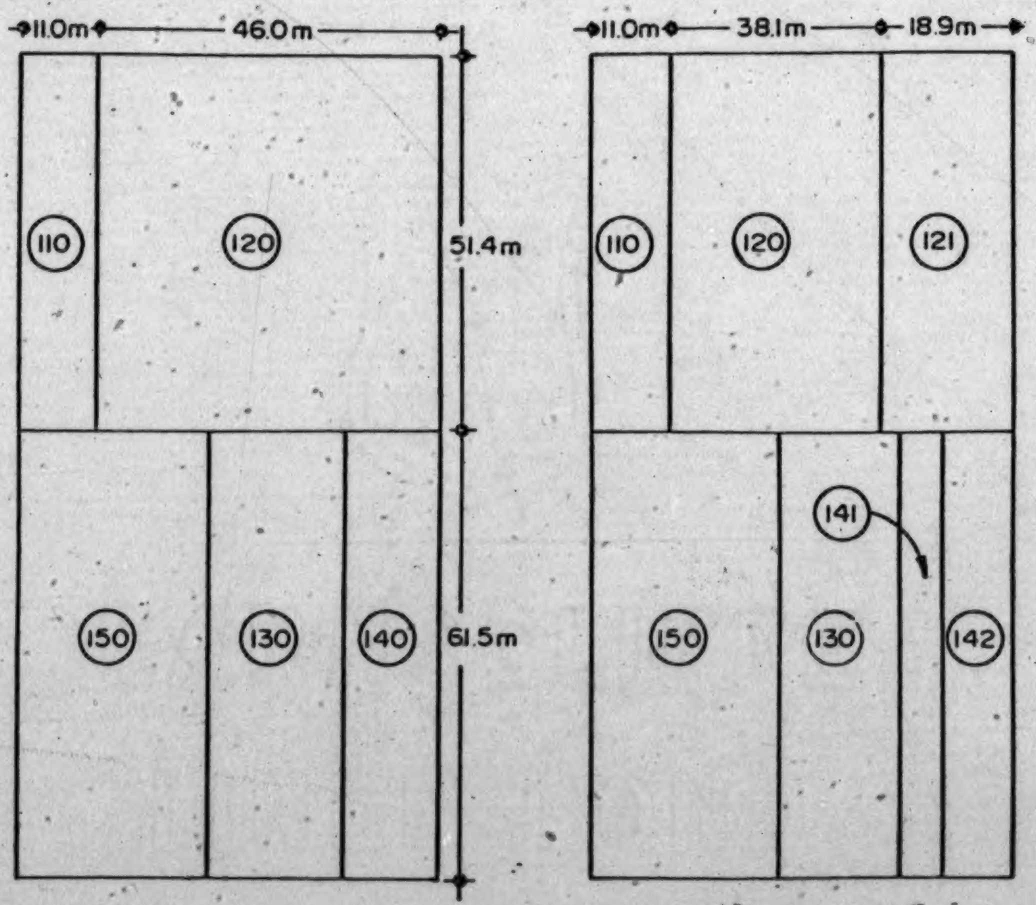
110	Rice
120	Maize x Hyacinth Bean
130	Rice
140	Sponge Gourd x Wing Bean x Tomato x Beans

SECOND CROPS

110	Maize
120	Hyacinth Bean
130	Fallow
132	Garlic x Bitter Gourd
140	Sponge Gourd x Wing Bean

FIGURE VI-2

CROPS ON PARCEL 25-1 IN CALE,
TANAUAN, BATANGAS, 1974-75


11.0m
46.0m
110
120
51.4m
150
130
140
61.5m
11.0m
38.1m
18.9m
110
120
121
141
150
130
142

FIRST CROPS

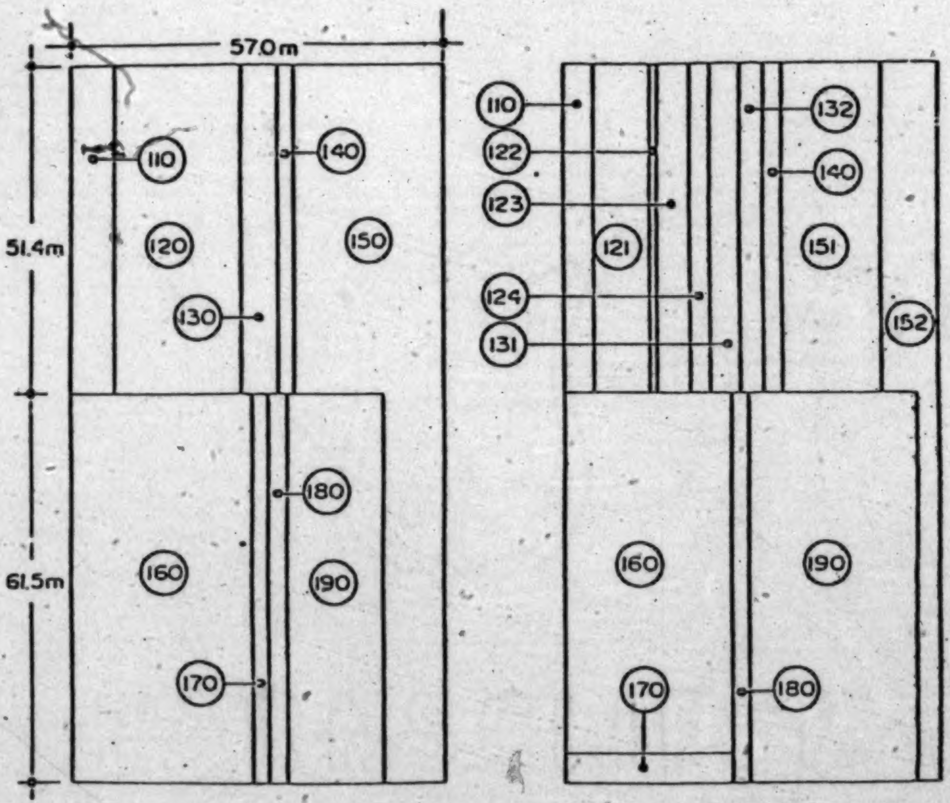
110 Maize x Hyacinth Bean
120 Rice
130 Eggplant
140 Rice
150 Sponge Gourd

SECOND CROPS

110 Hyacinth Beab
120 Maize
121 Garlic x Bitter Gourd
130 Eggplant
141 Cassava
142 Squash

FIGURE VI-3

CROPS ON PARCEL 25-1 IN CALE, TANAUAN, BATANGAS, 1975-76


57.0m
51.4m
61.5m
110
120
130
140
150
160
170
180
190
110
122
123
121
124
131
132
140
151
152
160
190
170
180

FIRST CROPS

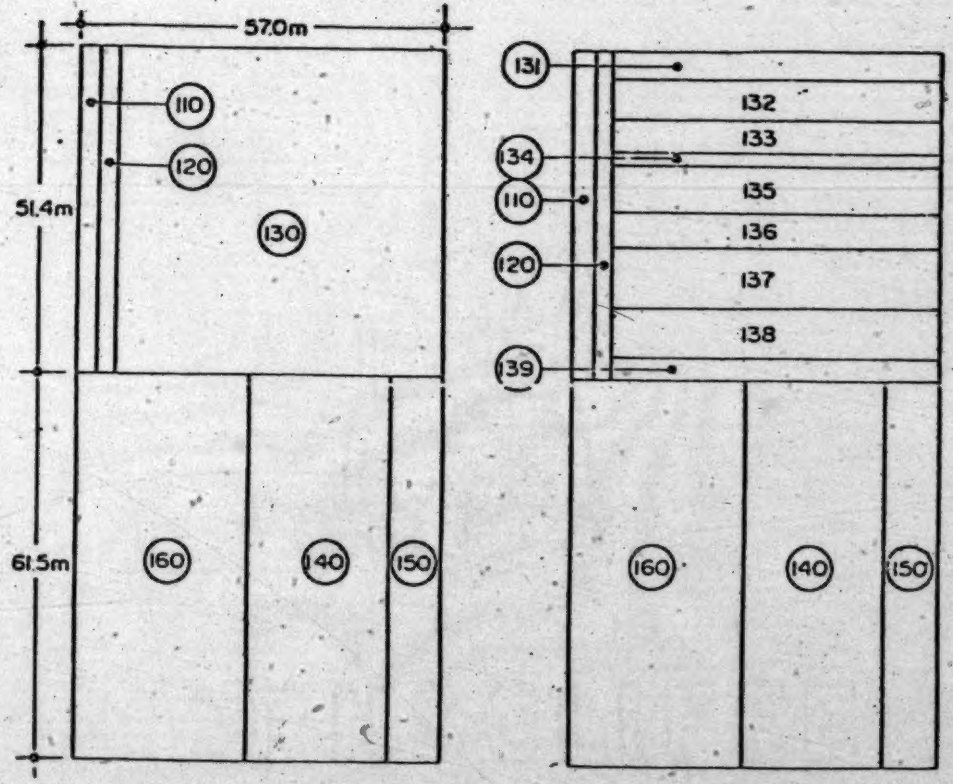
110 Maize
120 Rice
130 Fallow
140 Cassava
150 Eggplant
160 Bottle Gourd x Wing Bean
170 Ginger
180 Maize
190 Rice

SECOND CROPS

110 Tomato
121 Bitter Gourd
122 Garlic
123 Bitter Gourd
124 Cowpea
131 Bitter Gourd
132 Peanut x Bitter Gourd
140 Pepper
151 Cowpea
152 Maize
160 Bottle gourd x Wing Bean x Sponge Gourd
170 Ginger
180 Tomato
190 Maize

FIGURE VI-4

CROPS ON PARCEL 25-1 IN CALE, TANAUAN, BATANGAS, 1976-77


57.0m
51.4m
61.5m
110
120
130
160
140
150
131
132
133
134
135
136
137
138
139
110
120
160
140
150

FIRST CROPS

110	Cassava
120	Peanut
130	Rice
140	Eggplant x Squash
150	Maize x Squash
160	Sponge Gourd x Squash x Bottle Gourd

SECOND CROPS

110	Cassava
120	Fallow
131	Cassava
132	Sweet Potato
133	Cowpea
134	Sweet Potato
135	Squash
136	Bitter Gourd
137	Bitter Gourd
138	Garlic x Bitter Gourd
140	Garlic x Squash
150	Hyacinth Bean
160	Squash

problem, standard times can be used as coefficients except for harvesting and weeding, which can vary substantially. When calculated on a per hectare basis, these small plots often give extremely high coefficients but when kept in absolute terms do not change the over-all outcome very much, as they are insignificant in relation to the total farm.

Although the farms are small they are quite complex. The cropping patterns combine into cropping systems, and these form part of the farming system. A typical farming system that will be studied in more detail later, is shown in a schematic diagram (Figure VI-5). Initially, the farmer starts the season with a set of resources. He can allocate the resources shown by lines to three enterprises. In addition, he can make use of share labour and land. The cash market will give credit to be used by the family or in an enterprise. In the first period, the farmer put 2,800 pesos into the market and took an additional 400 pesos in credit, which he paid back after the harvest of the second crop. In the first crop period, share labour, i.e. labour which works for a specific share of the crop, put eighty hours into the crop enterprise and received 400 kg of rice. No data was collected on the crop residue used by the draft animals. The farmer had a good year as he ended with 1,640 pesos and one tonne of rice more than he started the year with.

This type of chart is useful in describing a system but is of little use in detailed analysis. A more detailed diagram can be developed for the cropping system part of the farming system but it becomes very complicated and is again of little use in analysis (Figure VI-6). However, diagramming a cropping system in this way, gives the researcher a clearer understanding of the flow of resources

FIGURE VI-5 FARMING SYSTEM (FARMER No. 20)

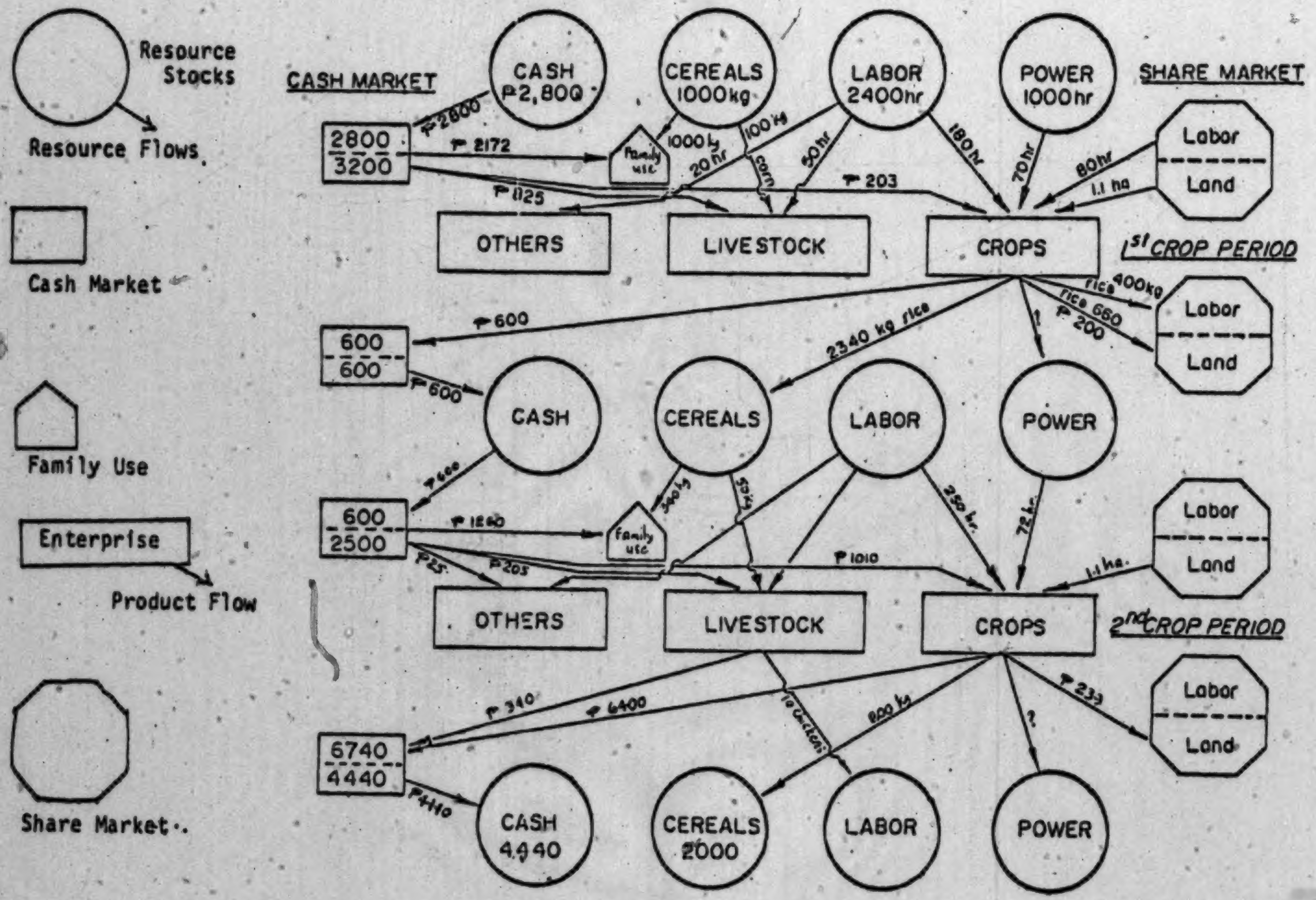
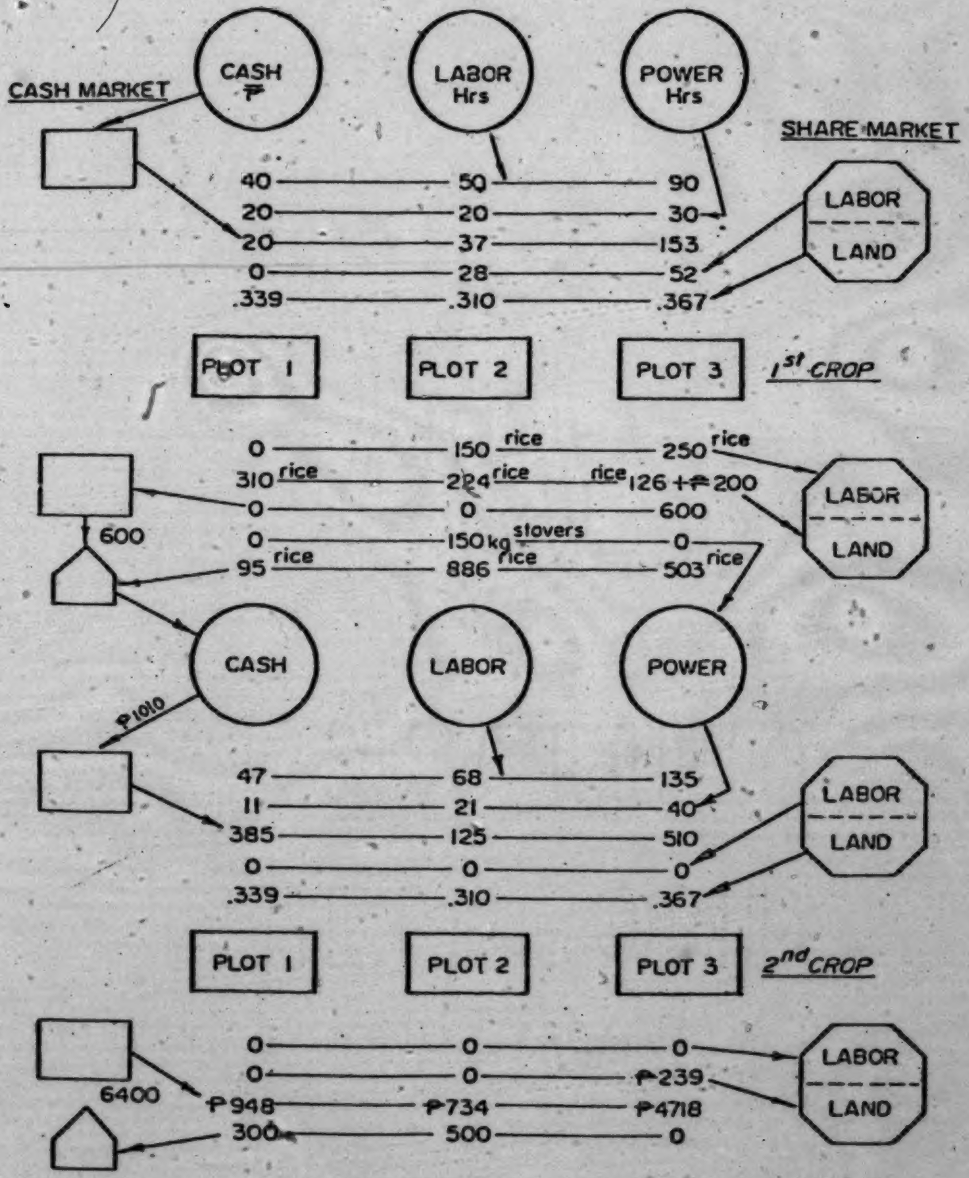

Resource Stocks
Resource Flows
Cash Market
Family Use
Enterprise
Product Flow
Share Market
CASH MARKET
SHARE MARKET
CASH ₱2,800
CEREALS 1000kg
LABOR 2400hr
POWER 1000hr
2800
3200
₱2800
₱ 2172
family use
1000 kg
100 kg
20 hr
corn
50 hr
180 hr
70 hr
80 hr
1.1 ha
₱ 203
₱ 1125
Labor
Land
OTHERS
LIVESTOCK
CROPS
1st CROP PERIOD
rice 400kg
rice 660
₱ 200
?
2340 kg rice
₱ 600
600
600
₱ 600
CASH
CEREALS
LABOR
POWER
₱ 600
600
2500
₱ 1260
family use
300 kg
50 kg
250 hr.
72 hr.
1.1 ha.
₱ 1010
₱25
₱ 205
OTHERS
LIVESTOCK
CROPS
2nd CROP PERIOD
₱ 340
₱ 6400
10 chickens
800 kg
?
₱ 233
6740
4440
₱4410
CASH 4440
CEREALS 2000
LABOR
POWER

FIGURE VI-6 CROPPING SYSTEM (FARMER No. 20)


CASH MARKET
CASH ₱
LABOR Hrs
POWER Hrs
SHARE MARKET
40 50 90
20 20 30
20 37 153
0 28 52
.339 .310 .367
LABOR
LAND
PLOT 1
PLOT 2
PLOT 3
1st CROP
0 150 rice 250 rice
310 rice 224 rice rice 126 + ₱ 200
0 0 600
600
0 150 kg stovers 0
95 rice 886 rice 503 rice
LABOR
LAND
CASH
LABOR
POWER
₱1010
47 68 135
11 21 40
385 125 510
0 0 0
.339 .310 .367
LABOR
LAND
PLOT 1
PLOT 2
PLOT 3
2nd CROP
0 0 0
0 0 ₱239
6400
₱948 ₱734 ₱4718
300 500 0
LABOR
LAND

to enterprises and the return to these resources. It also helps in understanding the high level of interaction between the household and farm activities particularly for cash requirements. A diagram such as this can also be used to show the effect on family welfare that different land tenure systems can have. These diagrams require a lot of time to complete and can only be completed for a few farms. In Figure VI-6 each column of numbers above a plot are the factors of production, while the numbers below the plot show the return to each of the factors of production. Diagrams such as these might be completed for five farms but could not be done for thirty farms.

Cost and Returns from Farm Data

All farms

Once a basic understanding of the farm and its activities has been obtained, the next step is a cost and return analysis of the major crops. Rice is the major crop in Cale. The farmers grow a traditional upland cultivar known locally as Dagge, which gives a stable yield of around 1.8 tonnes/ ha (Table VI-2). The rice cultivation procedure used in Cale is peculiar to the area. About two weeks after emergence, the fields are harrowed diagonally to pull out the weeds. Dagge has a quick growing deep root system which will hold the plants while the weeds are pulled. Only one new cultivar C-171 has been found which will stand this procedure.

The high coefficient of variation found for most of the factors of production are typical of small rice farms in Asia. The effects of these high coefficients of variation on analysis will be studied in more depth later. The costs and returns for maize over the four-year period have greater yield fluctuations than rice (Table VI-3). Maize is the

TABLE VI-2

COSTS AND RETURNS FOR RICE IN CALE, 1973-1977 (P/ha)

	1973-74 (67)[a]			1974-75 (66)		
	Cash	Imputed	C.V.	Cash	Imputed	C.V.
COSTS						
Materials						
Seed (kind)		120			120	
Pesticides	1					
Fertilizer	110	—	88	206	—	91
Sub-Total	111	120		206	120	
Labour						
Land preparation family		41	121		116	113
Cultivation family		71	417		51	74
Weeding family		196	403		156	104
hired	10		2,298	11		4,154
Harvesting family		150	2,724		106	109
hired (kind)	529	—	3,609	204	—	114
Sub-Total	539	458		215	429	
Land Rental (b)						
Family		500			268	
Landlord (kind)	500			268		
TOTAL COST	1,150	1,078		689	817	
Gross Returns	2,998		102	1,608		91
Return over cash and kind costs	1,848			919		
Return over all costs	770			102		
Return per peso spent	1.6			1.3		
Return per hour family labour		2.7			1.2	

(a) Number of plots observed

(b) Calculated on the basis on one-third to land after cash costs and share labour payment removed and one-half of land owned by operator

TABLE VI-2 (continued)

1975-76 (61)			1976-77 (75)			4-year mean (269)		
Cash	Imputed	C.V.	Cash	Imputed	C.V.	Cash	Imputed	C.V.
	120			120			120	
1								
276	—	181	265	—	92	207	—	134
277	120		265	120		207	120	
	84	115		70	213	78	78	136
	40	66		47	82		53	186
	173	101		13	106		181	170
10		604	34		269	16		384
	99	130		76	101		110	291
442	—	101	428	—	97	396	—	219
452	396		462	206		412	422	
	660			515			484	
660			515			484		
1,389	1,176		1,242	814		1,117	970	
3,961		96	3,090		93	2,858		171
2,572			1,848			1,784		
1,396			1,007			814		
1.9			1.5			1.6		
	4.5			5.9			3.6	

TABLE VI-3

COSTS AND RETURNS FOR MAIZE IN CALE, 1973-1977 (P/ha)

	1973-74			1974-75		
	(79)[a]			(69)		
	Cash	Imputed	C.V.	Cash	Imputed	C.V.
COSTS						
Materials						
Seed (kind)	13	47		33	27	
Pesticides	1			6		
Fertilizer	221	___	85	341	___	126
Sub-Total	235	47		380	27	
Labour						
Land preparation family		56	103		66	92
Cultivation family		42	96		48	151
Weeding family		60	123			106
hired	4					
Harvesting family		50	102		51	126
hired (kind)	79	___	86	93	___	172
Sub-Total	83	208		93	165	
Land Rental (b)						
Family		174			236	
Landlord (kind)	174			236		
TOTAL COST	492	429		709	401	
Gross Returns	1,389		68	1,887		156
Return over cash and kind costs	897			1,178		
Return over all costs	468			777		
Return per peso spent	1.8			1.7		
Return per hour family labour		3.2			3.9	

(a) number of observations

(b) Calculated on the basis on one fifth to land after cash costs removed and one half of land owned by operator

TABLE VI-3 (continued)

1975-76 (73) Cash	Imputed	C.V.	1976-77 (83) Cash	Imputed	C.V.	4-year mean (304) Cash	Imputed	C.V.
48	18		56	4		38	24	
1			0			2		
399	—	94	496	—	91	366	—	143
448	18		552	4		406	24	
	86	91		58	116		66	98
	43	106		38	130		42	116
	70	156		58	182		64	138
	82	138		76	189		65	156
56		118	71		123	74		96
56	281		71	230		74	237	
	247			335			250	
247			335			250		
751	546		958	569		731	511	
1,976		67	2,682		187	1,996		113
1,225			1,724			1,265		
679			1,158			754		
1.6			1.8			1.7		
	3.4			6.0			4.2	

second crop and has to compete with vegetables for the farmer's resources; consequently its yields are partially a function of vegetable yields and prices. While maize competes with vegetables for land, analysis showed that farmers input levels were near optimum for both crops. A cursory observation indicated low input levels for some maize. This was discovered to be related to input levels into the previous rice crop rather than indicating a shortage of inputs to maize. Maize does require less labour and shows a higher return per hour of labour than rice or vegetables (Table VI-4).

The vegetable grouping contains over thirty different crops ranging from radishes which take only a few weeks, to gourds which continue to grow over both crop periods (Appendix 2). The farmers mix the vegetables in a variety of ways, and over 100 cropping patterns were found on thirty-six farms. The vegetables are high risk in terms of both yields and price. For example, during the week of 16-23 September, 1979, the price of eggplant dropped by 50 percent. Farmers abandon fields if the price drops below harvest costs or insect damage becomes too great. The risk associated with vegetables is further exemplified by garlic, which is grown by many farmers. Garlic area and returns were analyzed in Table VI-5. It costs about 3,000 pesos/ha to establish a crop of garlic. Due to the tremendous fluctuations in price and yield, many farmers lost money while a few made over 20,000 pesos/ha. It was of interest that yield had no relationship to area planted, nor number of years experience.

The costs and returns in Table VI-4 cover all fields whether harvested or not. Since there is a mixture of crops, no coefficient of variation was calculated as some crops such as garlic, with very high costs would dominate. Over the four-year period, vegetables gave good

TABLE VI-4 COSTS AND RETURNS FOR VEGETABLES IN CALE, 1973-77 (P/ha)

	1973-74 (159)[a]		1974-75 (149)		1975-76 (191)		1976-77 (211)		Mean 4 years (710)	
	Cash	Imputed	Cash	Imputed	Cash	Imputed	Cash	Imputed	Cash	Imputed
COSTS										
Material										
Seed	79		103		63		228		124	
Pesticides	16		61		32		53		41	
Fertilizer	169		513		387		404		370	
Sub-total	264		677		482		685		535	
Hired Labour	35		188		66		40		77	
Family Labour	—	720	—	1,092	—	925	—	961	—	925
Sub-total	35	720	188	1,092	66	925	40	961	77	925
Land[b]										
Family		466		948		472		566		598
Landlord	155		316		157		189		199	
TOTAL COSTS	453	1,186	1,181	2,040	705	1,397	914	1,527	811	1,523
Gross Returns	3,726		7,584		3,776		4,525		4,787	
Return over cash costs	3,272		6,403		3,071		3,611		3,976	
Return over all Costs	2,086		4,363		1,674		2,084		2,453	
Return per peso	7.2		5.4		4.4		4.0		5.1	
Return per hour family labour		3.9		5.0		2.8		3.2		3.6

[a] Number of observations

[b] Calculated on basis on one sixth to land after cash costs removed assuming 75 percent of vegetable land owned by operator

TABLE VI-5

PLANTED AREA AND GROSS RETURNS FROM GARLIC IN CALE BASED ON THIRTY-TWO FARMERS

	1973-74	1974-75	1975-76	1976-77
Number who grew garlic	17	21	8	12
Minimum area planted (m^2) Maximum area planted (m^2)	90; 1,980	210; 2,250	50; 3,200	170; 1,420
Mean area planted (m^2)	880	1,200	940	830
Minimum Gross Returns (P/ha) Maximum Gross Returns (P/ha)	404; 31,350	2,800; 17,778	3,200; 14,718	2,462; 34,182
Mean Gross Return (P/ha)	10,395	9,882	7,024	13,253
Gross Returns/ha S.D.	8,739	6,401	3,919	9,178

returns to most farmers. In 1974-75, the drought that damaged the rice crop was worse in the vegetable growing areas in the northern Philippines and prices rose to a high level. Late rains gave the Cale farmers good vegetable yields which more than compensated for the low prices.

The costs and returns tables for rice, maize and vegetables give a general idea of the input-output relationships. Notable is the high variability of inputs and lower variability of outputs for rice and maize. The mean return per hour of family labour for four years is about the same for all three crops. The return to cash inputs is about the same for rice and maize but much higher for vegetables, indicating the risk premium for vegetables.

Five Farms

Collecting and analyzing the data for over thirty farmers requires a lot of resources, which most of the ACSN sites do not have.

Consequently, it was decided to analyze a small number of farmers to find if the same conclusions would be obtained as using the larger number. A test group of five farmers was selected by an IRRI research assistant, as being typical of the majority of farmers in Cale. The data of these farmers was analyzed individually for each of the four years, 1973-1977. (Tables VI-6; VI-7; VI-8; VI-9; VI-10) The maize and vegetables were combined as the farmers grow these to sell, while they grow rice to eat.

It may be useful to look at individual experiences of individual case study farmers. 1974-75 showed high returns due to high vegetable prices, which more than compensated for the low rice yields. Farmer 50 had an extremely high income in the first year as he had a large area in garlic, experiencing both high yields and prices. In the third and fourth years, he gave up part of the land he was renting, so his son could farm.

The tables (VI-6 to VI-10) show two main characteristics of the farmers. First, analysis of the four year time series indicates a high variability for inputs for an individual farm. Secondly, the income variability was lower. It would appear the farmers have the ability to stabilize income regardless of price and yield fluctuations. Variability was greater between farmers in the same year than for an individual farm over time. This suggests that cross-section studies are likely to overestimate the variance a farmer can expect for most of the key variables. This explains in part the high coefficient of variation for inputs in the costs and returns for over thirty farmers (Table VI-2).

More important is the variation in output. The coefficient of

TABLE VI- 6

INPUT BY SOURCE AND PRODUCTION FOR FARMER 18, CALE 1973-77

	1973-74		1974-75		1975-76		1976-77	
	Rice	Maize & Veg.	Rice	Maize & Veg.	Rice	Maize & Veg.	Rice	Maize & Veg.
Family Inputs								
Cash (P)	39	352	51	554	75	438	90	538
Labour (hrs)	111	446	189	356	90	448	119	439
Land (ha)[a]	0	0	0	0	0	0	0	0
Share Inputs								
Labour (hrs)	120	0	58	0	89	0	100	0
Land (ha)[a]	.671	1.143	.506	.843	.543	.901	.494	1.128
Rented area (ha)	.923		.923		.923		.923	
Production	kg	P	kg	P	kg	P	kg	P
Family	366	2,439	135	2,911	374	3,074	411	2,908
Share labour	120	0	36	0	107	0	91	0
Share land	231	475	48	508	162	593	178	578
Family Share -cash cost	366	2,048	135	2,306	374	2,561	411	2,280
Return to family cash[b] (P)	6.3		4.3		6.1		4.8	
Return to family labour[c] (P)	4.7		4.6		5.9		5.3	
Return to share labour[d] (P)	1.6		1.0		1.9		1.5	
Return to share land[e] (P)	915		634		923		935	

[a] Area cropped

[b] $$\frac{\text{(Family Rice Production x 1.6) + (Family Maize + Vegetable Production - Family Labour)}}{\text{Family Cash Input}}$$

[c] $$\frac{\text{Total Value of Family Production - Family Cash Inputs}}{\text{Family Labour}}$$

[d] $$\frac{\text{Product Value to Share Labour}}{\text{Share Labour}}$$

[e] $$\frac{\text{Product Value to Share Land}}{\text{Actual Area Share Rented}}$$

TABLE VI-7

INPUT BY SOURCE AND PRODUCTION FOR FARMER 20, CALE 1973-77

	1973-74		1974-75		1975-76		1976-77	
	Rice	Maize & Veg.	Rice	Maize & Veg.	Rice	Maize & Veg.	Rice	Maize & Veg.
Family Inputs								
Cash (P)	90	284	190	520	338	291	93	275
Labour (hrs)	295	349	307	397	313	463	213	426
Land (ha)[a]	0	0	0	0	0	0	0	0
Share Inputs								
Labour (hrs)	305	0	63	0	146	0	368	0
Land (ha)[a]	.953	.717	.873	1.057	.718	1.014	.82	.829
Rented area (ha)	1.059		1.059		1.059		1.059	
Production	kg	P	kg	P	kg	P	kg	P
Family	557	1,228	303	4,368	562	1,984	938	1,621
Share labour	270	0	63	0	121	0	274	0
Share land	230	231	154	836	183	393	426	317
Family Share -cash cost	557	854	303	3,658	562	1,355	938	1,253
Return to family cash[b] (P)	3.9		5.8		3.4		3.1	
Return to family labour[c] (P)	2.7		5.9		2.9		2.7	
Return to share labour[d] (P)	1.4		1.6		1.3		1.2	
Return to share land[e] (P)	565		1,022		648		943	

---

[a] Area cropped

[b] $$\frac{\text{(Family Rice Production x 1.6) + (Family Maize + Vegetable Production - Family Labour)}}{\text{Family Cash Input}}$$

[c] $$\frac{\text{Total Value of Family Production - Family Cash Inputs}}{\text{Family Labour}}$$

[d] $$\frac{\text{Product Value to Share Labour}}{\text{Share Labour}}$$

[e] $$\frac{\text{Product Value to Share Land}}{\text{Actual Area Share Rented}}$$

TABLE VI-8

INPUT BY SOURCE AND PRODUCTION FOR FARMER 24, CALE 1973-77

	1973-74		1974-75		1975-76		1976-77	
	Rice	Maize & Veg.	Rice	Maize & Veg.	Rice	Maize & Veg.	Rice	Maize & Veg.
Family Inputs								
Cash (P)	37	316	93	352	163	293	90	294
Labour (hrs)	378	827	301	461	228	638	260	515
Land (ha)[a]	0	.133	0	.133	0	.133	0	.133
Share Inputs								
Labour (hrs)	140	0	0	0	111	0	34	0
Land (ha)[a]	.613	.78	.5	.167	.445	.504	.455	.476
Rented area (ha)	.85		.85		.85		.85	
Production	kg	P	kg	P	kg	P	kg	P
Family	708	2,459	144	2,412	430	3,095	579	3,184
Share labour	210	0	0	0	0	0	41	0
Share land	342	562	45	342	164	541	261	469
Family Share -cash cost	708	2,106	144	1,967	430	2,639	579	2,800
Return to family cash[b] (P)	5.3		4.1		6.1		8.4	
Return to family labour[c] (P)	2.3		2.8		3.7		4.6	
Return to share labour[d] (P)	2.4		NA		1		1.9	
Return to share land[e] (P)	1,305		487		945		1,043	

---

[a] Area cropped

[b] $$\frac{\text{(Family Rice Production x 1.6) + (Family Maize + Vegetable Production - Family Labour)}}{\text{Family Cash Input}}$$

[c] $$\frac{\text{Total Value of Family Production - Family Cash Inputs}}{\text{Family Labour}}$$

[d] $$\frac{\text{Product Value to Share Labour}}{\text{Share Labour}}$$

[e] $$\frac{\text{Product Value to Share Land}}{\text{Actual Area Share Rented}}$$

TABLE VI-9

INPUT BY SOURCE AND PRODUCTION FOR FARMER 32, CALE 1973-77

	1973-74		1974-75		1975-76		1976-77	
	Rice	Maize & Veg.	Rice	Maize & Veg.	Rice	Maize & Veg.	Rice	Maize & Veg.
Family Inputs								
Cash (P)	168	358	587	900	313	1,375	403	793
Labour (hrs)	378	841	646	1,666	396	1,210	621	796
Land (ha)[a]	0	.066	0	.066	0	.066	0	.066
Share Inputs								
Labour (hrs)	776	0	321	0	503	0	579	
Land (ha)[a]	.984	1.076	1.029	1.546	1.137	1.498	1.465	1.286
Rented area (ha)	1.171		1.171		1.171		1.171	
Production	kg	P	kg	P	kg	P	kg	P
Family	1,370	2,456	1,026	7,255	749	4,865	1,795	3,746
Share labour	401	0	334	0	213	0	513	0
Share land	633	533	328	1,251	276	1,066	772	620
Family Share -cash cost	1,370	1,930	1,026	5,768	749	3,177	1,795	2,550
Return to family cash[b] (P)	6.3		4.4		2.6		3.3	
Return to family labour[c] (P)	3.3		3.2		2.7		2.9	
Return to share labour[d] (P)	0.8		1.7		0.7		1.4	
Return to share land[e] (P)	1,320		1,516		1,287		1,584	

---

[a] Area cropped

[b] $$\frac{\text{(Family Rice Production} \times 1.6) + \text{(Family Maize + Vegetable Production - Family Labour)}}{\text{Family Cash Input}}$$

[c] $$\frac{\text{Total Value of Family Production - Family Cash Inputs}}{\text{Family Labour}}$$

[d] $$\frac{\text{Product Value to Share Labour}}{\text{Share Labour}}$$

[e] $$\frac{\text{Product Value to Share Land}}{\text{Actual Area Share Rented}}$$

TABLE VI-10

INPUT BY SOURCE AND PRODUCTION FOR FARMER 50, CALE 1973-77

	1973-74		1974-75		1975-76		1976-77	
	Rice	Maize & Veg.	Rice	Maize & Veg.	Rice	Maize & Veg.	Rice	Maize & Veg.
Family Inputs								
Cash (P)	66	212	229	454	172	300	167	854
Labour (hrs)	391	1,677	314	1.042	199	567	246	810
Land (ha)[a]	.733	1.131	.883	.907	.19	.537	.289	.529
Share Inputs								
Labour (hrs)	273	0	311	0	140	0	284	0
Land (ha)[a]	.25	.417	.138	.225	.339	.339	.344	.498
Rented area (ha)	.88		.69		.69		.69	
Production	kg	P	kg	P	kg	P	kg	P
Family	1,954	7,073	1,420	10,050	689	3,260	1,021	3,260
Share labour	367	0	244	0	84	0	240	0
Share land	387	363	25	159	122	255	181	186
Family Share -cash cost	1,954	6,795	1,420	9,367	689	2,788	1,021	2,239
Return to family cash[b] (P)	25.8		15.7		5.4		3.0	
Return to family labour[c] (P)	4.4		8.4		3.7		3.0	
Return to share labour[d] (P)	2.2		1.3		1.0		1.4	
Return to share land[e] (P)	1,116		228		652		854	

[a] Area cropped

[b] $$\frac{\text{(Family Rice Production} \times 1.6) + \text{(Family Maize + Vegetable Production - Family Labour)}}{\text{Family Cash Input}}$$

[c] $$\frac{\text{Total Value of Family Production - Family Cash Inputs}}{\text{Family Labour}}$$

[d] $$\frac{\text{Product Value to Share Labour}}{\text{Share Labour}}$$

[e] $$\frac{\text{Product Value to Share Land}}{\text{Actual Area Share Rented}}$$

variation (CV) was .96 for the five farmers over the four years while the five individual farmers had CV's of .10, .37, .21, .28, and .55 respectively over the same period. It would appear that cross-sectional data has been overestimating the variation in returns to the farmer by two or three times. In the agronomy trials that were managed by farmers there was probably also an overestimation of variance as these were analyzed cross-sectionally.

Transferring Income Variability

Although the crop returns to a farm family are fairly stable, the returns to share labour and share land appear to have a high degree of variability. Results show the return to share labour varied by 100 percent and to share land by 50 percent (Table VI-11). The usual share system in Cale gives one-sixth of the rice yield to the harvesters. The landlord gets one-third of the rice yield after the harvesters' share and fertilizer costs have been subtracted. There is no share labour on the other crops. The landlord gets between one-quarter and one-sixth of other crops after fertilizer costs have been subtracted.

The calculations in Table VI-11 are based on gross returns over four years for each farmer. Then the mean share each received, and the standard deviation from that share over the four years was calculated. The tenant and sharing system at Cale shows that share labour accounts for a disproportionate percentage of the variation in production. Since share labour is only used for rice harvesting, the family that has a poor crop may decide to harvest most of it themselves, although this is considered antisocial. What most families do, is to make sure that all family members participate in the harvest of their own fields so they get a substantial part of the one-sixth.

TABLE VI-11

CROP PRODUCTION DISTRIBUTION TO FARM FAMILY, LANDLORD AND SHARE WORKERS FOR FIVE FAMILIES OVER FOUR YEARS, CALE, 1973-77 (P/FARM)

Farmer	Family Share		Landlord		Share Labour	
	Mean	S.D.[a]	Mean	S.D.	Mean	S.D.
18	2,724 (71)	1,032	841 (22)	235	291 (7)	171
20	2,813 (75)	290	786 (21)	134	142 (4)	59
24	3,122 (77)	652	803 (20)	290	128 (3)	146 (13)
32	5,332 (72)	1,495	1,516 (20)	222	584 (8)	201
50[b]	7,331 (89)	4,044	527 (6)	328	374 (5)	186
Mean	(77)		(18)		(5)	

[a] Standard Deviation

[b] Farmer owns 56 percent of area farmed

( ) Percent

The share harvest system is an old tradition that gives village families a chance to secure rice if their own crops have failed. Rarely are outsiders allowed to participate in a harvest. The landlord consistently gets one-fifth of the crop. But there is no clear pattern regarding the sharing of production variation. The analysis shows that on average, the five farmers managed to pass on 5 percent of the variation in income during the four years uder review. A detailed analysis of the thirty-six farmers was not done but there is no reason to expect

TABLE VI-12

ACTUAL INPUT AND PRODUCT OF FIVE FARMS OVER FOUR YEARS IN CALE

		INPUTS					
		Land			Labour		
Farmer	Year	Rice (ha)	Maize (ha)	Vegetables (ha)	Rice (hrs)	Maize (hrs)	Vegetables (hrs)
18	1973-74	.671	.671	.432	231	336	391
	1974-75	.506	.186	.657	267	36	320
	1975-76	.543	.397	.504	179	67	381
	1976-77	.494	.705	.421	219	167	272
20	1973-74	.953	.392	.325	600	105	244
	1974-75	.873	.628	.429	370	101	296
	1975-76	.718	.510	.504	459	99	364
	1976-77	.820	.371	.458	581	155	271
24	1973-74	.613	.596	.317	518	158	669
	1974-75	.500	.084	.216	301	64	397
	1975-76	.445	.268	.348	339	57	581
	1976-77	.455	.182	.311	294	38	454
32	1973-74	.984	.877	.265	1,154	227	614
	1974-75	1.029	.949	.663	967	179	1,487
	1975-76	1.137	1.075	.513	899	296	914
	1976-77	1.465	.535	.841	1,200	77	719
50	1973-74	.983	.534	.722	664	114	1,539
	1974-75	1.021	.485	.647	625	53	989
	1975-76	.529	.339	.154	339	25	542
	1976-77	.633	.469	.436	530	141	669
	$\bar{X}$	.769	.512	.458	537	125	606
	SD	.279	.258	.178	307	85	375

TABLE VI-12 (continued)

Cash			PRODUCT			
Rice (P)	Maize (P)	Vegetables (P)	Rice (P)	Maize (P)	Vegetables (P)	Crop Gross Return
39	24	328	1,147	528	2,386	4,061
51	88	466	350	311	3,108	3,769
75	256	182	1,029	747	2,920	4,696
90	368	170	680	967	2,519	4,166
90	70	214	1,619	548	1,138	3,305
190	179	341	832	1,178	4,026	6,036
338	166	125	866	1,135	1,242	3,243
93	126	149	2,621	593	1,345	4,559
37	58	258	2,016	1,411	1,610	5,037
93	80	272	302	654	2,100	3,056
163	166	127	1,062	489	3,147	4,698
90	99	195	1,410	250	2,758	4,418
168	255	103	3,846	1,300	1,658	6,804
587	239	661	2,701	1,392	7,123	11,216
313	774	601	1,981	3,631	2,300	7,912
403	268	525	4,928	594	3,772	9,294
66	114	98	4,333	1,068	6,368	11,769
229	156	298	2,702	1,563	8,646	12,911
172	62	238	1,432	761	2,754	4,947
167	150	704	2,307	1,049	2,004	5,360
173	185	302	1,908	1,008	3,146	6,062
142	164	190	1,299	726	2,020	2,986

the results to be much different since the sharing arrangement is on a percentage basis.

Factors of Production

The next step in the analysis is to study the factors of production for each crop. A review of Table VI-12 shows that most of the farmers adjusted their maize and vegetable crops to compensate for variation in rice yields. The correlation coefficients between rice yields and maize plus vegetable gross returns are -.36, -.63, +.19, -.89, and +.54 for the five farmers over four years. If all five farms are considered together, the correlation coefficient is - .38. Since these are only four observations per farmer the correlation coefficients are not statistically significant at the 5 percent level. Of twenty-five sample farmers who grew all three crops sixteen had negative correlation coefficients between rice yields and maize plus vegetable gross returns with nine less than -.5. Although not statistically significant a trend appears to be forming worth more investigation. Out of the twenty-five it was found that those with a negative correlation coefficient had a mean crop gross income of 5,309 pesos while those with a positive correlation coefficient had a mean gross income of 8,572 pesos. The difference was significant at the 1 percent level. The five case study farmers showed the same pattern. As a further test of the hypothesis that small farmers work harder in the face of rice yield variability, a correlation was run between cash inputs for maize and vegetables, and rice yields per farm over a four-year period. The correlation coefficients are -.94, -.56, -.57, -.67, and -.34. Again the correlation coefficients are not statistically significant due to low number of observations. A negative sign would indicate that farmers put more cash into the second season crop if they got a low rice yield. Conversely, if they got a good rice crop they did not put a lot of cash into the second seasons crops.

During a discussion with farmers in September 1979 they were asked about use of inputs following a poor rice crop. They confirmed that they would likely try for greater production in the second crops but said the final decision would depend upon market prices particularly for the vegetables.

In summary, although not shown statistically the evidence indicates that income maintenance is a farmer's major goal and that there is a danger in using aggregate data when specific relationships must be understood.

Variability in Factors of Production

Farm record-keeping data is notorious for the variability that can be found in it. It was decided to check the record data of all the farmers for the four-year period to gain an understanding of the variability and distribution characteristics of their input-output coefficients. First, the factors associated with inputs were studied (Table VI-13). The table shows several important problems. First, the arithmetic mean overestimates the input level for the majority of farmers. Since a few high values can bias an arithmetic mean upwards it is a biased estimator for inputs, if the objective is to describe what the majority of farmers are using. The geometric mean is shown to be a better estimator, while the harmonic mean biases the estimator down when there are some very low values.

The second results of the analysis of inputs is that kurtosis and skewness measures are unreliable. The area owned per farm shows a kurtosis of 2.71 and skewness of 0.47 with 140 observations. This meets all tests

TABLE VI-13

FREQUENCY DISTRIBUTION CHARACTERISTICS OF INPUTS AND INPUT RATIOS FOR CROP PRODUCTION IN CALE, 1973-77

	Cropped area/ Farm (ha)	Area in rice /Farm (ha)	Area in maize /Farm (ha)	Area in vegetable /Farm (ha)	Area owned /Farm (ha)	Hired Labour /Farm (hrs)
N	130	130	130	130	140	137
Mode	1.75	.5	.5	.225(a) and .525	.875(a) and 1.625	50
Arithmetic Mean	2.06	.818	.717	.563	1.23	375
Geometric Mean	1.63	.627	.518	.438	1.04	244
Harmonic Mean	1.15	.421	.330	.310	0.78	145
Standard Deviation	1.28	.525	.521	.370	0.61	309
Kurtosis	3.23	2.98	3.85	3.84	2.71	2.97
Skewness	0.85	.718	1.03	.992	0.47	1.92
Chi Square Test of Normality	19.3*	10.4	16.8*	16.7*	19.2*	45.1*
With Degree of Freedom	8	8	8	8	9	9

*Significant at 5 percent

(a)bimodal

TABLE VI- 13 (continued)

Total Labour /Farm	Total Labour hrs/ Cropped/ha /Farm	Total Labour hrs /Farm ha /Farm	Family members available for farm work	Fertilizer costs /ha /Farm	Land Value /Farm	Family labour/ Farm
(hrs)	(hrs)	(hrs)	(man years)	(PIH)	(PIOT)	(hrs)
135	128	136	137	128	128	128
1,050	700	900	0.9	2.8	12.5	695
1,327	760	1,160	1.5	3.36	17.9	1,018
1,082	653	1,016	1.1	2.72	15.5	821
804	565	865	.09	2.17	13.16	651
771	463	540	1.1	3.12	10.6	582
2.51	6.64	2.67	3.83	12.5	5.82	3.22
0.62	1.86	0.42	1.16	2.96	1.67	0.77
20.2*	39.5*	6.34		5.96	76.8**	13.2
9	7	9		5	5	7

**Significant at 1 percent

of normality and yet the distribution is clearly bimodal. There thus appears to be little value in running normality tests. Using a chi square test of normality, eight out of the twelve inputs were found not normally distributed, suggesting the chi square test is a better test for samples over 100. Although somewhat subjective due to the decision on class intervals the chi square test was much more sensitive to bimodal problems than tests of kurtosis and skewness.

When the distribution characteristics of output were tested, the results were much the same (Table VI-14). The arithmetic mean overestimated what the majority of farmers would get. The geometric mean was a better estimator and the harmonic mean showed a tendency to underestimate. The kurtosis and skewness measures were unreliable as a test for normality and the chi square test also appears to be unreliable when the number of observations falls to twenty or thirty. The chi square test, for example, did not identify the bimodal distribution of rice yields in 1974-75 when the number of observations was twenty-seven. This is mainly due to the statistical requirement that there will be at least five counts in each of the expected cells. Once the number of observations increased the chi square test became quite sensitive.

In summary, Tables VI-13 and VI-14 show some of the data problems with farm record-keeping data. Since most sites will have a relatively small number of observations in the first several years there is no good test of normality. However, graphing the data will often show distribution problems that cannot be found with regular normality tests. The arithmetic mean is a poor estimator and the geometric mean should be considered for describing characteristics of inputs and products.

TABLE VI-14 FREQUENCY DISTRIBUTION CHARACTERISTICS OF OUTPUT FOR CROP PRODUCTION IN CALE; 1973-77

	Rice Yield kg/ha/farm					Four-year Gross Ret/ha/plot			
	1973-74	1974-75	1975-76	1976-77	All four years	Rice (P)	Maize (P)	Veg. (P)	All crops (P)
N	26	27	27	27	107	125	126	134	134
Mode	1,850	450[a] and 1,600	1,650	1,850	500[a] and 1,750	750[a] and 2,750	1,000	2,500	3,125
Arithmetic Mean	2,058	1,096	1,919	1,874	1,734	2,070	1,203	3,545	5,476
Geometric Mean	1,928	847	1,750	1,760	1,494	1,573	888	2,664	4,299
Harmonic Mean	1,819	654	1,617	1,616	1,206	1,066	611	1,829	3,020
Standard Deviation	836	881	941	593	623	1,348	888	2,542	3,472
Kurtosis	9.85	9.6	7.78	2.6	5.83	2.43	3.67	4.13	2.94
Skewness	2.22	2.33	2.04	- .245	1.73	0.58	1.10	1.19	0.81
Chi Square Test of Normality	3.6	4.2	3.1	3.2	18.6**	19.1*	20.4**	23.1**	21.0*
Degree of Freedom	4	4	4	4	6	8	6	8	9

*5 percent significance **1 percent significance

[a] bimodal

Independence

Checking factors of production for independence can be done examining their correlation coefficients. The more important factors and their correlations are shown in Table VI-15. Since many of the correlation coefficients were significant there is a problem of interdependence, which needs to be examined further. One method to handle this problem is to consider a specific quantity of inputs as a package. In this study inputs were considered as an input package.

Homogeneity

The basic factors of production are land, labour, and capital. In most analyses these are assumed to be homogeneous. This assumption can create problems in analysis and in trying to apply the results. Analysis was therefore undertaken to test the assumption of land homogeneity.

In the original 1973 Cale baseline study each farmer was asked to establish an area and value for each of his parcels of land. These areas were later checked and actual parcel size recorded. This resulted in three estimators for land, farm size, cropped area, and value of cropped area.

Correlation coefficients can be used to test for the best estimators. Table VI-15 shows that the correlation coefficients for land value and crop gross returns was .63 while cropped area was .73. Farm size was not tested and since not all parcels are cropped twice, it is assumed there is a low relationship. Thus, for aggregated data, cropped area is suggested as the most accurate estimator of land input.

A test for labour homogeneity was conducted by having three people working at the site divide the farmers into three groups according

TABLE VI-15

CORRELATION COEFFICIENTS BETWEEN FACTORS AFFECTING CROP PRODUCTION IN CALE, 1973-77[a]

	Land value	Family labour	Total labour	Percent land owned	Cropped area	Fertilizer costs
Family labour	.518					
Percent land owned	-.207	-.133				
Cropped area	.730	.664	.798	-.248		
Fertilizer cost	.503		.654	-.100	.619	
Total labour	.603					
Crop care	.410				.578	.435
Crop care x LC	.448			-.125	.628	.476
Total labour x LC					.790	

[a] Based on thirty-two farmers over four years. Values less than .146 non-significant at 5 percent.

LC Labour Coefficient

to diligence. In descending order of diligence the group were assigned a labout coefficient of 1, .8, and .6. The product of the actual hours and labour coefficient was then correlated with crop gross returns from the farm. The correlation with the LC was higher indicating labour is not homogeneous in crop production.

The final input tested for homogeneity was cash input. Cash inputs were found to have a low correlation with crop output. Actual physical input measures gave higher correlations. This suggests that there was a wide variation between farms in costs per unit of input, indicating farmers' varying ability to buy cash inputs at their lowest costs. Fertilizer is the main cash input, making up 90 percent of cash inputs.

The conclusion is that land, labour, and capital are not homogeneous on farms in one village. If a specific process is to be studied it is important that accurate estimators be used. Whenever possible, actual physical units should be used and even these may have to be subdivided on the basis of quality.

The Case Study Approach

The basic assumption in choosing a case study approach rather than an aggregate approach is, that a detailed working knowledge of a few farms is of more use in making decisions on new technology, than a broad overview with a few aggregate relationships defined. The economists at the ACSN sites do not have the resources to complete a detailed study of a large sample. The key question is: Would a large sample of a few critical factors be superior to a detailed study of a few farms?

The foregoing discussion demonstrated some of the problems that will be encountered with an aggregate approach, namely:

1. Arithmetic means are not representative of the majority of farmers. Since most frequency distributions found on a farm are skewed, there will be a continual overestimation of inputs and outputs using arithmetic means.
2. The interactions between input-input, input-output and output-output relationships obtained from aggregate data will not only give an inaccurate understanding of the relationships the individual farmer

faces, but could give the opposite sign to the relationship, thus leading the research in the wrong direction.

3. Farm data is highly variable, nonhomogeneous, and not independent, making it unsuited for econometric procedures used in aggregate analysis.
4. Aggregate cross-sectional analysis overestimates the variability an individual farmer faces. A small time series study gives a more reliable understanding. However, decisions must be made in the first year at the site and cross-sectional analysis can perform a useful function in this instance.

In addition, there is another important reason for using case studies in the ACSN. The economist acquires a fund of informal knowledge of the farm and how it works. Most agricultural economists in Asia come from the city, and have little farm experience. Continual personal interaction with a small number of farmers gives them a much better understanding of farming than large-scale, impersonal interviews.

The main problem with the case study approach is selecting representative or modal farms. This problem can usually be solved by consulting with people knowledgeable about the community and the farmers, and weighing their suggestions against their vested interests. Mistakes can be made in farm selection but, given the present situation in the ACSN, the case study approach appears to be the best alternative.

Pretesting Informal Procedures

In this section the informal procedures were pretested, using data from Cale. Following the procedures discussed earlier, the first step was to compare the alternatives by using budgets. The resource requirements were then graphed to determine any major constraints.

The final step was to use program planning in determining to what extent the new technology should be adopted by the farmers.

Several new crops were introduced in Cale to replace maize. One of these was sorghum, which will be used in the pretest. Sorghum had the advantage that it could be harvested in 85 to 100 days and if sufficient moisture is available, a ratoon crop is possible. In 1975-76, twenty parcels were planted to sorghum. The recommended agronomy practices were explained to the farmers who participated in the research.

Although the costs and returns for sorghum did not appear promising, some farmers wanted to continue its production (Table VI-16). The main reason for this was the high yield of over three tonnes/hectare, that some farmers got. They were aware that most of the low yields were due to poor stand establishment caused by inadequate land preparation. Since inadequate land preparation can be improved, it was decided to drop the ten parcels which had low yields, and compare the results of the ten high-yielding plots with maize. The third column in Table VI-16 shows the costs and returns for these ten high-yielding plots.

Budgets

Using the data from Table VI-16, a partial budget was used to compare the feasibility of replacing maize with sorghum (Table VI-17). Sorghum costs more to grow than maize since added costs are greater than reduced costs. However, the added income from sorghum is greater than the reduced income from the maize it would replace. Since the economic advantage was greater than the disadvantage by only P198/hectare, the analysis would normally stop here, as the economic advantage appears

TABLE VI-16

COMPARISON OF EXPERIMENTAL DATA FOR SORGHUM AND FARMERS' DATA FOR MAIZE IN CALE, 1975-76

(P/ha)

Cost	Sorghum[a] Cash	Sorghum[a] Imputed	Sorghum[a] C.V.	Corn[b] Cash	Corn[b] Imputed	Sorghum[c] Cash	Sorghum[c] Imputed
Materials							
Seed	85		45	28	38	86	
Pesticides	15		133	3		15	
Fertilizer	446		60	403	—	533	
Sub-total	546			434	38	634	
Labour							
Land preparation		143	50		72		171
Maintenance		22	148		51		16
Weeding		21	157		78		31
Harvesting							
Family		70	50		88		82
Hired				64			
Hired threshing	113					143	
Land rental							
Family		67			90		104
Landlord	266		88	361		416	
TOTAL COST	925	323		859	417	1,193	404
Gross return	1,533		53	1,803		2,308	
Return							
Over cash cost	608			944		1,115	
Over-all cost	285			527		711	
Per peso spent	1.3			1.6		1.6	
Per hour family labour		2.1			2.8		3.4

[a]Based on twenty parcels

[b]Based on fifty-eight parcels

[c]Based on ten high yielding plots

TABLE VI-17

PARTIAL BUDGET TO COMPARE MAIZE WITH SORGHUM BASED ON
FIFTY-EIGHT PARCELS OF MAIZE AND TEN OF SORGHUM,
CALE, 1975-76
(P/ha)

	Cash	Imputed		Cash	Imputed
Added Costs			Reduced Costs		
Materials	634		Materials	434	38
Labour		300	Labour		289
Threshing	143		Harvesting	64	
Landlord	416		Landlord	361	
	1,193	300		859	327
Reduced Income			Added Income		
	1,803	0		2,308	
	2,996	300		3,167	327
Economic Disadvantage	3,296		Economic Advantage	3,494	

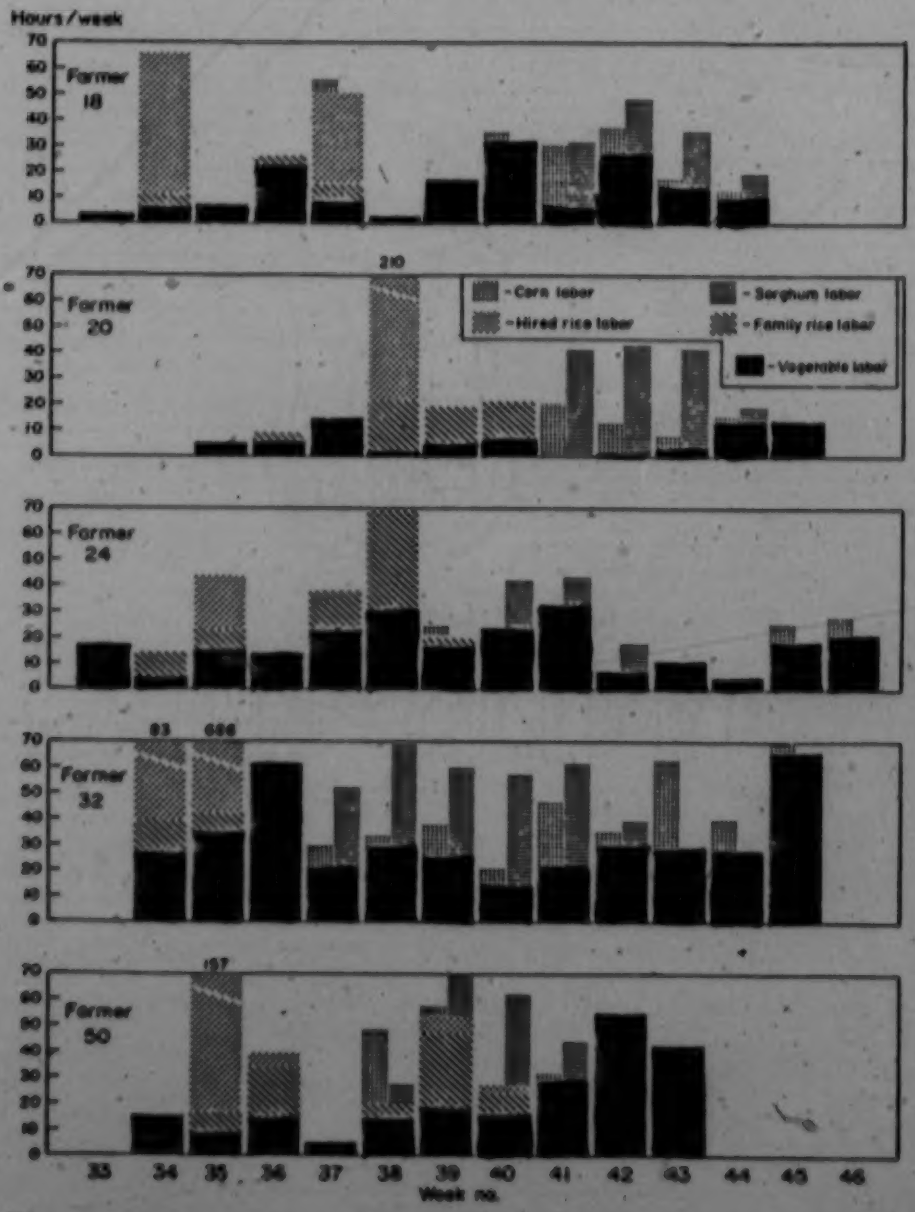
insufficient to expect the farmers to adopt sorghum. But, since the farmers had indicated an interest, further analysis was justified.

Graphs

The next step in the procedure is a graph of labour use, comparing the two crops following a rice crop (Figure VI-7). Sorghum did require more land preparation than maize for all farmers, and it required it at a time when most farm families were busiest harvesting rice and planting vegetables. There would be pressure on the farmers to do hurried, most likely inadequate, land preparation for sorghum so they could work on the vegetables. As seen in the preceding paragraphs, this results in poor yields. Thus, although the labour requirement

FIGURE VI-7

COMPARISON OF MAIZE AND SORGHUM LABOUR USE AT PLANTING FOR FIVE FARMERS IN BO. CALE, TANAUAN, BATANGAS



Comparison of corn and sorghum labor use at planting for five farmers in Bo. Cale, Tanauan, Batangas.

does not actually exceed the labour available, it should be considered a limiting factor. Harvesting sorghum is more laborious than maize, but since there is little other work at that time, this is no problem.

Program Planning

The next procedure is program planning. In Table VI-18 an initial matrix is shown using mean data for maize and for the best ten sorghum plots. The constraints are those found on an average farm. To ensure that both maize and sorghum could come into the solution, the data were calculated on 50 m^2 land units. The first solution B uses all sorghum. As more maize is added, the solution gross margin falls, but so do cash expenditures. Finally, in solution F, all maize is planted, and the loss in gross margin is compensated for by the reduced cash expenditure. It would appear from this analysis that the average farmer would gain nothing from planting sorghum, and would be facing a larger risk due to the higher cash and labour input.

Each of the five case study farmers was then used to compare the maize and sorghum. The maize and sorghum data were taken from Table VI-19 for the year 1975-76 for each farmer. Only Farmers 18 and 24 required program planning analysis since the other three farmers had maize gross margins higher than sorghum and nitrogen costs were the same or lower, so there was no possibility sorghum could enter the solution. Farmer 18 would not plant all the maize area to sorghum, as he had a land preparation constraint in weeks 42 and 43 (Table VI-20). There was a possibility of moving the land preparation to other weeks, to plant the remaining area. By planting various combinations of maize and sorghum he could get a slightly higher gross margin, but it seemed likely he would grow all maize shown in solution F. If the farmer could

TABLE VI-18

PROGRAM PLANNING COMPARING MEAN DATA FOR MAIZE AND SORGHUM DATA, CALE, 1975-76

	Gross Margin	Land[a]	Cash	Labour Land Prep.	Limits
INITIAL MATRIX					
Activity					
Sorghum	4.46	1[b]	2.54	.684	39.37/ cash
Maize	3.77	1	1.89	.288	40/land
Resources available		40	100	30	
SOLUTION B					
Sorghum	175.59	39.37	100	26.93	
SOLUTION C					
Sorghum	156.1	35	88.9	23.94	
Maize	18.85	5	9.45	1.44	
Resources	174.95	40	98.35	25.38	
SOLUTION D					
Sorghum	133.8	30	76.2	20.52	
Maize	37.7	10	18.9	2.88	
Resources	171.5	40	95.1	23.4	
SOLUTION E					
Sorghum	89.2	20	50.8	13.68	
Maize	75.4	20	37.8	5.76	
Resources	164.6	40	88.6	19.44	
SOLUTION F					
Maize	150.8	40	75.6	11.52	

[a] Assuming 2,000 m^2

[b] One unit of land 50 m^2

TABLE VI-19 COMPARISON OF FIVE FARMERS' ACTUAL MAIZE DATA WITH SORGHUM EXPERIMENTAL DATA FOR SAME AREA, CALE, 1975-76

Farmer	18		20		24		32		50	
	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum
Area (ha)	.397	.397	.485	.485	.225	.225	1.004	1.004	.339	.339
Plant date (week)	42	42	43	43	45	45	42	42	43	43
N (kg)	43	48	37	59	31	27	113	120	10	41
N cost (P)	180	201	157	250	135	118	407	432	52	213
Land Prep. (hrs)	15	65	31	83	0	38	45	172	0	58
Cultivation (hrs)	6	0	4	0	7	0	11	0	4	0
Weeding (hrs)	0	8	0	10	2	7	0	31	0	11
Harvest (hrs)	47	85	105	109	40	51	116	227	26	76
Yield	747	939	1,126	1,189	414	613	3,142	2,473	760	831
Gross returns	747	837	1,126	1,070	414	552	3,142	2,225	760	748
Over cash	567	636	969	820	279	434	2,735	1,793	708	535
To landlord	142	159	242	205	70	109	689	448	177	134
To family	425	477	727	615	209	294	2,056	1,345	531	401
To labour (hrs)	6.25	3.02	5.19	3.04	4.27	3.06	11.92	3.13	17.7	2.76

TABLE VI-20

PROGRAM PLANNING FOR FARMER 18 COMPARING SORGHUM WITH CURRENT MAIZE PRODUCTION, 1975-76

	Gross Margin	Land	Cash	Labour by week			
				41	42	43	44
INITIAL MATRIX Activity							
Sorghum	12.7	1[a]	4.0	.3	.4	.4	.17
Maize	11.3	1	3.6	.36	.1	.08	.02
Resources available		50	180	25	15	21	20
SOLUTION B							
Sorghum	476	37.5	150	11.25	15	15	6.375
SOLUTION C							
Sorghum	381	30	120	9	12	12	5.1
Maize	188	16.7	60	6	1.7	1.33	.33
Resources	569	46.7	180	15	13.7	13.33	5.43
SOLUTION D							
Sorghum	355.6	28	112	8.4	11.2	11.2	4.76
Maize	213.4	18.9	68	6.8	1.9	1.5	.38
Resources	569	46.9	180	15.2	13.1	12.7	6.14
SOLUTION E							
Sorghum	317.5	25	100	7.5	10	10	4.25
Maize	251.1	22.2	80	8	2.2	1.77	.44
Resources	568.6	47.2	180	15.5	12.2	11.77	4.69
SOLUTION F							
Maize	565	50	180	18	5	4	1

[a] one unit of land is 80 m^2

get more money, he could plant an additional 240 m^2, and get 1.4 pesos for each peso spent on sorghum in solution C.

Farmer 24 proved to be the one farmer who could gain from growing sorghum (Table VI-21). In 1975-76 he used more nitrogen on maize than the average for sorghum, so nitrogen was not a constraint. Sorghum had a definite advantage over maize for him as the gross margin for sorghum was 55 percent higher than maize. In solution B he would grow all the sorghum he could until he hit the week 41 labour constraint. For each additional hour of labour he could use in week 41, he would gain 15.5 pesos. He could easily hire labour for less than this. Thus, sorghum shows a real potential for Farmer 24.

Although the group data showed little advantage for sorghum, individual analysis showed a definite advantage for one farmer. It is likely that this farmer was typical of the few farmers who were interested in sorghum.

Comparison of LP and Informal Procedure Solutions

The final test of the informal procedure is to compare its solution with LP based on data from two other sites, Iloilo and Pangasinan. A detailed description of the LP model and the assumptions used are given in Barlow et al.[1] Their matrix had 378 rows and 643 columns. The main activities were: crop production, crop consumption, crop sale, other earnings, household expenditure, loans, family labour, transfer labour, hiring, water buffalo hire, cash saving and cash surplus. The resources were three categories of land, two categories of labour, cash, water buffalo and a set of constraints relating to family needs.[2] Two sets of technology were defined. Farmers' technology were the practices used by the farmer in 1975-77. New technology was that being

TABLE VI-21

PROGRAM PLANNING FOR FARMER 24 COMPARING SORGHUM WITH CURRENT MAIZE PRODUCTION, CALE, 1975-76

	Gross Margin	Land	Labour by week					
			39	40	41	42	45	46
INITIAL MATRIX								
Activity								
Sorghum	8.7	1[a]	0	.36	.2	.2	0	0
Maize	5.6	1	.1	0	0	0	.12	.12
Resources available		45	12	14	6	26	19	17
SOLUTION B:								
Sorghum	261	30	0	10.8	6	6	0	0
Maize	84	15	1.5	0	0	0	1.8	1.8
Resources	345	45	1.5	10.8	6	6	1.8	1.8

[a] one unit of land is 50 m^2

tested by the IRRI cropping systems team during the same period. The coefficients used were arithmetic means from the agronomy experiments and case study farm data. The LP model was designed to first obtain a given amount of rice and then to maximize the net cash surplus.[3] Five case studies were run in Iloilo and Pangasinan with data from ten individual farms.

To ensure that the solution from the informal procedure was comparable with the LP solution, data was taken from the working tables used in developing the LP model. There was no way the informal procedure could handle the great mass of data used in the LP model. In consultation with research assistants who had worked at the sites, a set of assumptions were made regarding the critical factors:

1. to use only two land classifications--upland and lowland
2. to use only the first date when land preparation can start
3. to use only land preparation hours
4. to only consider fertilizer and chemicals in cash costs, and
5. the the highest gross return would be the decision criteria.

Two of the largest labour use activities were not used in the analysis since it is a common practice to hire labour for transplanting and harvesting.

One factor which complicated the analysis more than would normally occur was the large number of farmers and new technologies which had to be compared. The LP model included all crops the farmer had grown as well as all experimental crops. The budgeting phase of the procedure was therefore much larger than would be the case if a specific new technology could be compared with the specific farmers' technology it was to replace. In this case all farmers and all new technology had to be compared for one land classification at one planting period. In many cases this meant forty crops from which to select. The first step was to discard all crops which had low gross margins and high land preparation or cash requirements. The crops which remained were put in a budget comparison table.

Detailed Analysis of One Farmer

The process followed in the procedure will be discussed for Farmer 1, Iloilo. Those crops which were not clearly unprofitable were listed along with their critical factors, in a budget comparison, (Table VI-22). Each crop was given a code to facilitate analysis, with F for farmers' technology and N for new technology. The crops are divided into farmers' and new technology, upland and lowland, and first or second crop period. Since rice is the main crop considered, rice cultivars are shown by their letter and number codes. The two letters following the rice cultivar's name indicate seeding method. Transplanting (TP) is the traditional technology. Wet seeding (WS) and dry seeding (DS) are new technology. It should be noted that in the first year of testing DS and WS, several farmers adopted it and in the classification it was recorded as farmers' technology in the record-keeping. The land preparation start week is the first week ploughing can begin.

The initial matrix and solution for Farmer 1, Iloilo for the first crop period are shown in Table VI-23. F-6, F-7, and N-8 were the three crops selected for the upland area. The upland area was one hectare of five parcels of 2,000 m^2, which appeared to the modal parcel size for most farms. Therefore the solution could easily be interpreted into number of parcels.

A more precise solution could be achieved if one square metre

TABLE VI-22

BUDGET COMPARISON OF FARMERS AND NEW TECHNOLOGY FARMER 1, ILOILO. (/ha)

		L.Prep. start week	L.Prep. hrs	Cash P	GR P
Farmer's Technology					
Upland (UL)					
First crop					
F-6 Maize		16	94	117	1,390
F-7 Maize		16	94	0	610
Second crop					
F-8 Maize		45	221	0	469
F-9 Maize		45	221	117	1,044
F-10 Maize		32	330	0	2,455
Lowland (LL)					
First crop					
F-1 IR5	TP	23	124	177	1,469
F-2 Kapopoy	TP	21	203	187	1,537
F-4 BE 3	TP	23	203	335	1,926
Second crop					
F-5 BE 3	TP	34	244	218	934
New Technology					
Upland					
First crop					
N-8 Maize		16	145	252	1,877
Lowland					
First crop					
N-1 IR36	WS	18	138	404	2,009
Second crop					
N-3 Maize - Yam bean[a]		41	255	110	3,077
N-5 IR36	TP	36	190	420	1,699
N-7 Mung		41	88	257	723
N-4 IR36	TP	36	38	84	579

[a] can only be grown in 2,000 m^2.

Abbreviations:		
	L.Prep.	Land preparation
	TP	Transplant
	WS	Wet seeded

TABLE VI-23

INITIAL MATRIX AND SOLUTION FOR FIRST CROP PERIOD FARMER 1, ILOILO

		GR P	Land	Cash P	L.Prep. hrs	Land Preparation (week)				
						16	17	18	19	20
INITIAL MATRIX										
Activity										
F-6	UL	255	1[a]	23	19					
F-7	UL	122	1	0	19					
N-8	UL	325	1	50	29					
N-2	LL	274	1	81	40					
N-1	LL	321	1	81	34					
F-1	LL	258	1	35	32					
F-3	LL	198	1	43	40					
F-4	LL	318	1	67	50					
F-2	LL	270	1	37	50					
Resources available			UL 5 LL 3	350		48	48	48	48	48
SOLUTION										
N-8	UL	975	3	150		48	39			
F-7	UL	244	2	0					37	1
N-1	LL	642	2	162			9	48	11	
F-2	LL	270	1	37						37
Resources		2,131	UL 5 LL 3	349		48	48	48	48	38

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[a] 2,000 m^2

were used as the basic land area, but that would entail working with a lot of small decimals which would have little meaning to the researcher. By using a typical parcel area, the researcher can check his calculations with his experience from working with the farmers. Gross returns, cash, and land preparation hours, were all divided by five from the per hectare budget data before being entered in the program planning matrix. The land preparation hours column and the weeks in which they could be used were separated.

The land preparation weeks are those during which the researchers found the farmer had been or could carry out land preparation. After the weeks shown, the farmer would get substantially reduced yields or, in the case of lowland, fields might be flooded and no crop could be grown. The land preparation hours shown or multiples of them, can be used in any of the weeks shown. The possible crops for the lowland are shown below the upland crops. In this case, there are only three units, or 6,000 m^2 of lowland available. In the "resources available" row, the value for cash, P350 and the forty-eight hours per week are for both upland and lowland areas. Using the same procedure described above for comparing sorghum and maize a new optimal solution was found. The solution is shown at the bottom of Table VI-23. The upland area was planted to 6,000 m^2 N-8 and 4,000 m^2 F-7. The lowland area had 4,000 m^2 N-1 and 2,000 m^2 F-2. These crops gave a gross return of P2,131, used P349 in cash costs and used all the land preparation hours available for four weeks and most of the fifth.

The selection of crops for the second period becomes a little more complicated, as the duration of the frist crop must be taken into consideration. Since the first crop was usually rice or maize, it is not a major problem. The initial matrix and solution for the second crop period for Farmer 1, Iloilo, are given in Table VI-24. Both cash and land preparation time became major constraints, bringing the farmer's traditional early maize with no fertilizer into the solution.

The solutions for first and second crop periods are combined to show the cropping pattern solution in Table VI-25. The solution shows upland UL all planted to maize. All of the lowland (LL) is planted to rice except for one parcel of maize and yam bean intercropped. The solution shows 50 percent of the land in new technology and 67 percent of the rice being seeded by a new method. The new technology does appear to have a place in this farmer's cropping system.

The same process outlined above was used on the other four farms in Iloilo and on four additional farms in Pangasinan. One farm was omitted since it had grown a considerable area of sugar cane and there was not sufficient information to justify an analysis. The budget comparisons, program planning, and cropping pattern solutions for the eight farmers are shown in Appendix 3.

The Iloilo Site

A comparison of the program planning and linear programming solutions for Iloilo in Table VI-26 shows there was little difference in family income from crops. The differences were 11, 17, 17, 2 and 20 percent respectively. However this is of limited value since the LP model was able to give a far more complete picture by including off-farm income, family cash expenses, rice consumption and hired labour in its final solution.

The main objective of the comparison is to find if the new technology will fit into the farm and if so to what extent. A

TABLE VI-24

INITIAL MATRIX AND SOLUTION FOR SECOND CROP PERIOD
FARMER 1, ILOILO

		GR	Land	Cash	L.Prep.	Land Preparation (week)									
		P		P	hrs	32	33	34	35	36	37	38	39	40	41
INITIAL MATRIX															
Activity															
F-9	UL	185	1[a]	23	44										
F-10	UL	491	1	0	66										
F-5	UL	143	1	44	49										
N-3	LL	830	1	22	51										
N-4	LL	688	1	114	38										
N-5	LL	387	1	84	38										
N-6	LL	365	1	84	40										
N-7	LL	149	1	51	18										
Resources available			UL 5 LL 3	350		48	48	48	48	48	48	48	48	48	48
SOLUTION															
F-10	UL	491	1	0		48	18								
F-9	UL	740	4	92						2	48	48	48	30	
			5												
N-3	LL	830	1	22										18	4
N-4	LL	1,376	2	228			30	48	48	46					
Resources		3,437	UL 5 LL 3	342		48	48	48	48	48	48	48	48	48	4

[a] 2,000 m^2

TABLE VI-25

INFORMAL CROPPING PATTERN SOLUTION
FARMER 1, ILOILO

			Land in		Rice Land		
	Crop		New Technology	Farmer's Technology	DS or WS	TP	GM
First Crop Period							
N-8	Maize	UL	3				975
F-7	Maize	UL		2			244
N-1	Rice	LL	2		2		642
F-2	Rice	LL		1		1	270
Second Crop Period							
F-10	Maize	UL		1			491
F-9	Maize	UL		4			740
N-3	Maize - Yam Bean	LL	1				830
N-4	Rice	LL	2			2	1,376
TOTAL			8	8	2	3	5,568

UL	Upland
LL	Lowland

TABLE VI-26

COMPARISON OF INFORMAL PROCEDURE AND LP SOLUTIONS FOR ILOILO

	Percent Area in New Technology		Percent Rice Area DS or WS		Family Income from Crops (P)	
	IP	LP	IP	LP	IP	LP
Farmer 1	50	82	67	21	5,568	6,264
Farmer 2	100	100	100	52	16,989	20,230
Farmer 3	75	71	79	100	15,605	18,706
Farmer 4	67	25	100	50	18,770	18,327
Farmer 5	71	59	12	75	11,783	9,825

IP Informal Procedure
LP Linear Programming

comparison of the two procedures for percent area in new technology show similar patterns. Farmer 2 would use all new technology and Farmer 3 would use new technology on about three-quarters of his land. The differences come with Farmers 1 and 4. In the case of Farmer 1 the limit on cash was partially removed by credit and off-farm income in the LP solution thus allowing more new technology. Farmer 4 had high family cash expenses which limited the cash available for new technology in the LP solution.

The percent area direct seeded or wet seeded showed more diversity particularly for Farmers 1 and 5. In all cases the major cause of difference was the family requirement for rice, which was included in the LP solution but not in the informal procedure.

The results of the informal procedure would lead to the same conclusions as linear programming. The new technology would benefit most of the farmers. With the prices and technologies considered, most of the farmers would use new technology on over one-half of their cropped area. Direct or wet-seeding would be used on over half of most farmers' rice area.

The Pangasinan Site

A comparison of the two procedures for Pangasinan shows a very different situation. Solutions have a higher family income from crops (Table VI-27). Farmer 2 only worked part-tine, and so labour was a major constraint in the linear programmin solution. Generally, labour constraints and outside activities caused the major differences. For Farmer 1 the informal procedure solution used much more new technology which pushed the cash surplus higher. The linear programming solution shows that new technology will not play a major role on the majority of these farms. The informal procedure solution shows the same thing.

TABLE VI-27

COMPARISON OF INFORMAL PROCEDURE AND LP SOLUTIONS FOR PANGASINAN

	Percent Area in New Technology		Percent Rice Area DS or WS		Family Income from Crops (P)	
	IP	LP	IP	LP	IP	LP
Farmer 1	38	5	40	4	15,424	9,034
Farmer 2	63	66	100	18	9,573	4,690
Farmer 3	100	37	75	56	13,908	11,358
Farmer 5	9	32	10	0	15,307	12,509

IP Informal Procedure

LP Linear Programming

In a comparison of direct and wet-seeding area, the informal procedure was far higher. Farmer 2 who only works part-time had a major difference. However, the informal procedure indicated that the new seeding methods would not be generally accepted and more research was needed. The conclusions from both procedures are that the new technology does not fit well and that more research is needed before general adoption will occur.

The results from informal procedure for Pangasinan are not as accurate as those for Iloilo because the author was not as familiar with this site as he was with those at Cale and Iloilo. As previously indicated, when using informal procedure, familiarity with the site is essential.

In summary, the analysis indicates that the informal procedure has lead to the same conclusions as LP. In one case the new technology was acceptable and in the other it was not likely to be adopted. This was the conclusion for both procedures. Although not as precise as LP it does appear that the informal procedures were as accurate. With practice the informal procedure should help economists make a greater contribution to cropping systems research.

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2. Ibid., p. 10.

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CHAPTER VII

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Food shortage is a problem now and in the foreseeable future in much of Asia. To help meet this problem cropping systems research has been developed at IRRI. The objectives of this study were:

1. to describe IRRI's cropping systems program with emphasis on the ACSN
2. to study the role of economics in the program and how the economist was fulfilling that role
3. to review and analyze some of the formal procedures used in analyzing farm data, and
4. to develop and test a set of informal procedures to use in the economic analysis of the testing phase of cropping systems research.

To meet the first objective, the development of IRRI's program was outlined and the current objectives and research procedures were discussed. The ACSN objectives and organization were then outlined, emphasizing the role of IRRI in the net work. The importance of the flow of information among the country programs and between the country programs and IRRI was stressed.

The second objective was met by carrying out a survey on the economists' training, and activities at the ACSN sites. In addition, a review of farm management principles and some of the disciplines associated with farm management provided a background for a better understanding of some of the problems encountered by economists in the ACSN. Specific problems faced by the economists were then identified and discussed.

Given these specific problems, the third objective of reviewing traditional farm data analysis procedures was undertaken to examine their suitability for cropping systems research analysis. Before the review was undertaken the research sites were described as well as the data collection methods. Aggregation problems were examined, and implications of aggregating across farms were compared to the use of case study farms over time.

A set of informal procedures was developed and pretested on data from one site and then tested on two other sites to meet the fourth objective. The informal procedure started with utilization of the partial budget. If the new technology was found to be less profitable than the farmers' existing technology, the analysis was concluded and the new technology rejected. If the new technology appeared profitable, the labour, power and cash requirements over time were graphed to identify potential constraints. The final step was to use program planning which involved the profitable alternatives, and constraints identified in the graphs. Solutions generated using the informal procedures were then compared to the more complex linear programming solutions to discover whether the same conclusions would be reached.

Conclusions

The cropping systems program at IRRI has played a major role in the development of cropping systems research in Asian countries.

The IRRI program has been instrumental in getting the systems approach accepted, and in supplying methodology suited for this approach. However, the economic component of the program was found to consist of analytical techniques which were not well suited to the ACSN sites. More data was being collected than could be effectively analyzed. Therefore, an improved procedure was required in terms of data collected, and analytical procedures more compatible with the expertise, time constraints and facilities at the sites.

While there appeared to be enough trained manpower to carry out the economics role at most sites, the economic methodology in use at the time of this study was causing frustration among the economists and their team members. First, the economic analysis was usually completed too late to be of use for decision-making. Secondly, in many cases, the results were incomplete. The economists felt they were not developing useful skills in their profession, nor contributing sufficiently to the team effort. The conclusion was that less time be spent in collecting farm record data, and more time on analysis.

Collection of less data requires a choice between a larger sample of fewer factors, or a smaller sample involving more factors. The traditional approach has favoured the large sample. Based on the farms covered in this study, the traditional approach was found to be unsatisfactory for effective evaluation of new technology in cropping systems research. Cross sectional studies were found to overestimate input and output variability that the individual farmers faces, by 300 percent when compared to time series studies of individual farmers.

Another problem that was found to occur when data is aggregated across farms, is that a false understanding of the interaction of enterprises can be formed. Aggregate data showed a positive relationship between gross returns of the first and second crop periods. But, a majority of individual farms showed a negative relationship. Thus, research based on aggregate analysis would be starting from a false premise.

Arithmetic means, the basis for nearly all analysis in the traditional approach, were found to overestimate input and output levels of the majority of farmers. Since most input and output calculations are ratios, i.e. kg/ha, the geometric mean was a better estimator for the majority. It was also found that kurtosis and skewness measures are unreliable tests for normality, particularly in the case of bimodal distributions. It was concluded that graphs of the frequency distribution should be used and if there are over 100 observations, a chi square test of normality could be considered. After a series of tests it was concluded that the three main factors of production: land, labour, and capital are not homogeneous nor independent. It was therefore concluded that a package of inputs was of more use in analysing farm data for comparison with agronomy research results.

When a comparison between the farmers' existing technology and new technology is to be made at a typical ACSN site, it was concluded that a case study approach is superior. Studying a small number of farms in detail gives a better understanding of the farm. The case study approach has several other advantages. First it allows a continuous interaction between the farmer and the researcher. Through this interaction the researcher understands the actual operational procedures and organization on a farm, and the reasons why certain decisions are made. Thus he builds on his informal knowledge of farming which can be used in the design phase of the research. Second, the interactions between enterprises can be studied. Unless a complete set of records is available for a farm, these interactions can be overlooked, and even if noted cannot be analyzed. Third, by understanding the researcher's objectives, the farmer can contribute much more effectively to the research program. Fourth, by selecting a small number of farmers to study in detail, the researcher can plan his work so time is available to do special studies on problem areas.

Since one of the roles of the economist is to develop a framework for understanding and analyzing the farmers' cropping system, a schematic diagram was developed to meet this objective. A schematic diagram of the stock and flow of resources and products on a farm gives all members of a cropping system research team a better picture of how the farmer is using his resources and where the products are going. It can serve as a framework to plan research, and a model to test the effects of introducing new technology. The same type of diagram can be used to show a subsystem of a farm, such as a cropping system or cropping pattern.

By the time an economist has collected detailed data on a few farms, and worked through a couple of schematic diagrams he should have sufficient understanding of the farming operation to begin evaluating the effects of new technology. It is important that the person who has collected the data and gained the informal knowledge, do the analysis. This is particularly true for the informal procedure suggested in this study.

It was found that partial budgets are an effective tool for evaluating the probability of acceptance of new technology in an existing farm operation. They can be completed quickly and other team members can easily understand the procedure and results. Partial budgets are an efficient first step in the informal procedure, to weed out technologies which are inferior to those on the farm, and retain those which show promise.

Graphs are an effective method of finding constraints in resource use for a new technology found profitable. Graphs of resource use over time, can be quickly and easily constructed and understood. Graphs also show time periods when resources are under-utilized. This information can be used in designing new technology to make more efficient use of the farmers' resources.

Partial budgets and graphs can thus be used to assess the probable acceptance of a new technology. However, for a more complete analysis, program planning was found to be effective. Using the results of partial budgeting and graphing, program planning can be used to demonstrate to what extent the new technology is likely to be adopted. It also supplies a set of shadow prices which can be used in designing research for new technology. Although not as simple as partial budgets and graphs, program planning solutions can be obtained with the use of a hand calculator. Since program planning relies on the skill and knowledte of the researcher it should only be undertaken by someone familiar with the farms under study.

It was concluded that the informal procedure would lead to the same conclusions as linear programming in predicting the acceptance of new technology. At the Iloilo site, for example, both procedures predicted general acceptance of the new technology under review. This was borne out by farmers' actions. At Pangasinan the conclusion from both procedures was that the new technology would not be generally accepted without further research.

In summary, the over-all conclusion was that a case study approach helps ensure that the researcher will not collect more data than he can analyze and utilize. Use of the informal procedure of partial budgets, graphs, and program planning will allow analysis to be completed within one month on a typical ACSN site. This helps to ensure that economic results from the testing phase will be available for use in the design phase of cropping systems research.

Recommendations

1. A case study approach on a small number of typical farms at a site should be used. Each of the farms should be analyzed individually and the potential adoption of a new technology be tested on each farm.
2. It is recommended that an analysis of the cropping systems research can be most effectively conducted at the site to ensure interaction with farmers and other team members.
3. The evaluation of new technology should start with partial budgets to find if the new technology is profitable. Graphs should then be used to find constraints in resource use. Program planning should follow to evaluate likely adoption rates.
4. New technology should not be evaluated using aggregate farm data in the testing phase of cropping systems research.

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APPENDIX 1

SURVEY OF CROPPING SYSTEMS ECONOMIC METHODOLOGY

SURVEY OF CROPPING SYSTEMS ECONOMIC METHODOLOGY

by

Gordon R. Banta

	Site					
	1	2	3	4	5	6
1. Country ________________						
2. What year did agronomy experiments begin?						
(In the next 2 questions, use N if not completed.)						
3. How many months from the baseline survey was ffinished until the economic analysis was finished?						
4. How many months from the harvest of the last crop until the cost and return analysis was finished?						
A. First year at site						
B. Second year at site						
C. Third year at site						
5. In this question, I want to find out what economic tools are being used and where the analysis is being done. Base your answer on the last full year of research.						
For the following questions use S if done by person at site H if done by person at hdqtrs. B if done by both above X if not done						
A. Farm records data collection						
B. Economic component of experiments data collection						
C. Weekly or monthly summary of farm records						
D. Calculate means of inputs						
E. Calculate S.D. of inputs						
F. Cross tabulation of farmers' data						
G. Cost and returns of experiment data						
H. Cost and returns of farmers' data						
I. Returns to factors of production of farmers' data						
J. Returns to factors of production of experiment data						

	Site					
	1	2	3	4	5	6
K. Calculate production functions either data set						
L. Labor distribution over year of farmer's data						
M. Cash flow over year of farmer's data						
N. Whole farm budget of farmer's data						
O. Other (specify tool used)						
In the following question I want to find the level of training, where they were stationed and percent of working time spent on economics of the people who contributed to the economic component of the research. Base your answer on the last full year of research.						
Example if one B.Sc. works full time and one 25 percent of his time on economics put 125.						
6. People stationed in the site with						
A. M.Sc. or Ph.D.						
B. B. Sc.						
C. Diploma						
D. High School						
E. Others						
People stationed at the headquarters with						
F. Ph.D.						
G. M.Sc.						
H. B. Sc.						
I. Diploma						
J. High School						
K. Others						
7. Number of calculators at site economists can use						
A. Full time						
B. Part time						

8. Comments or Suggestions (Pls. continue on the back of this page if additional space is needed for writing.)

APPENDIX 2

COMMON ENGLISH AND SCIENTIFIC NAMES OF ANNUAL CROPS GROWN IN CALE, BATANGAS

Common English Name	Scientific Name
Beans	LEGUMINOSACEAE Vigna sesquipedalis Fruw.
Bottle Gourd	CUCURBITACEAE Lagenaria leucantha Rusby.
Bitter Gourd	CUCURBITACEAE Momorbica charantha Linn.
Cassava	EUPHORBIACEAE Manihot essulenta Crantz.
Cowpea	LEGUMINOSACEAE Vigan sinensus Endl.
Cucumber	CUCURBITACEAE Cucumis sativas Linn.
Eggplant	SOLONACEAE Solanun melongena Linn.
Garlic	LILIACEAE Allium sativum Linn.
Ginger	ZINGIBERACEAE Zingiber officinale Rosco.
Hyacinth Bean	Leguminosaceae Dolichos lablab Linn.
Lima Bean	LEGUMINOSACEAE Phaseolus lunatus Linn.
Maize	GRAMINACEAE Zea Mays Linn.
Mung Bean	LEGUMINOSACEAE Vigna radiati
Mustard	CRUCIFERACEAE Brassica integrifolia Rupr.
Onion	LILIACEAE Allium cepa Linn.
Okra	MALVACEAE Hibiscus esculentus Linn.
Peanut	LEGUMINOSACEAE Arachis hypogaea Linn.
Pechay	CRUCIFERACEAE Brassica chinensis Linn.
Pepper	SOLONACEAE Capsicum annuum Linn.
Pigeon Pea	LEGUMINOSACEAE Cajanus cajan Linn.
Radish	CRUCIFERACEAE Raphanus sativas Linn.
Rice	GRAMINACEAE Oryza sativa Linn.
Snake Gourd	CUCURBITACEAE Trichosanthes anguina Linn.
Sorghum	GRAMINACEAE Sorghum vulgare Pers.
Soybean	LEGUMINOSACEAE Glycine max Merr.
Sponge Gourd	CUCURBITACEAE Luffa aegyptiaca Mill.
Sweet Potato	CONVOLVULACEAE Ipomea batatis Poir.
Squash	CUCURBITACEAE Cucur bita maxima Duch.
Taro	ARACEAE Colocasia antiquorum Schott.
Tomato	SOLONACEAE Lycopersicum esculentum Mill.
Wax Gourd	CUCURBITACEAE Benincasa cerifera Savi.
Wing Bean	LEGUMINOSACEAE Psophocarpus tetra gonolobus DC.

APPENDIX 3

INFORMAL PROCEDURE ANALYSIS OF EIGHT CASE STUDY FARMERS

TABLE 3-1

BUDGET COMPARISON OF FARMERS AND NEW TECHNOLOGY FARMER 2, ILOILO. (/ha)

		L.Prep. start week	L.Prep. hrs	Cash P	GR P
Farmer's Technology					
Upland (UL)					
First crop					
F-1 Peanut		17	64	216	975
F-2 Sweet Potato		18	50	0	108
Second crop					
F-3 Glutinous corn		39	113	289	1,946
F-4 Corn + Yam bean		38	113	485	2,018
F-5 Peanut		35	113	200	1,470
F-6 Pigeon pea		33	113	195	1,000
Lowland (LL)					
First crop					
F-7 BE 3	TP	21	162	237	2,251
F-8 Kapopoy	WS	19	162	112	2,014
F-9 Glutinous rice	TP	21	162	189	1,518
Second crop					
F-10 IR20	TP	32	162	88	1,835
F-11 IR36	TP	35	165	150	2,784
F-12 IR36	WS	37	194	150	2,784
New Technology					
Upland					
First crop					
N-1 Corn	DMR	23	58	218	3,126
Second crop					
N-2 Sorghum		38	43	218	1,800
N-3 Peanut		37	113	629	2,025
Lowland					
First crop					
N-4 IR36	DS	19	162	222	2,474
N-5 IR36	TP	23	162	237	3,076
N-6 IR36	WS	20	162	237	2,942
Second crop					
N-7 IR36	TP	34	162	222	2,257
N-8 IR36	WS	35	162	222	2,501
N-9 Mung		42	70	99	3,000

Abbreviations: L.Prep. Land preparation WS Wet seeded
TP Transplant DS Direct seeded

TABLE 3-2

INITIAL MATRIX AND SOLUTION FOR FIRST CROP PERIOD FARMER 2, ILOILO.

		GR P	Land	Cash P	L.Prep. hrs	Land Preparation (week)							
						18	19	20	21	22	23	24	25
INITIAL MATRIX													
Activity													
N-1	UL	382	1[a]	44	12								
F-2	UL	22	$\frac{1}{9}$	0	10								
N-6	LL	541	1	47	32								
F-8		380	1	22	32								
Resources available			9	1,500		48	48	48	48	48	48	48	48
SOLUTION													
N-1[b]	UL	3,056	8	352	96							48	48
N-6	LL	4,869	9	423	288	48	48	48	48	48	48		
Resources		7,925	17[b]	775		48	48	48	48	48	48	48	48

[a] $2000m^2$

[b] Since he has sufficient cash he would hire the L.Prep. on one hectare.

TABLE 3-3

INITIAL MATRIX AND SOLUTION FOR SECOND CROP PERIOD FARMER 2, ILOILO.

	GR	Land	Cash	L.Prep.	Land Preparation (week)					
	P		P	hrs	35	36	37	38	39	40
INITIAL MATRIX										
Activity										
F-5 UL	254	1[a]	40	23						
N-2 UL	316	1	44	9						
		9								
F-11 LL	527	1	30	33						
N-9 LL	580	1	20	14						
Resources available		9			48	48	48	48	48	48
SOLUTION										
N-2 UL	3,844	9	396					18	48	15
N-9 LL	5,220	9	180			48	48	30		
Resources	9,064	18	576		48	48	48	48	48	15

[a] 2000m^2

TABLE 3-4

INFORMAL CROPPING PATTERN SOLUTION
FARMER 2, ILOILO

		Crop		Land in New Technology	Land in Farmer's Technology	Rice Land DS or WS	Rice Land TP	GR
First Crop Period								
	N-1	Corn	UL	8				3,056
	N-6	Rice	LL	9		9		4,869
Second Crop Period								
	N-2	Sorghum	UL	9				3,844
	N-9	Mung	LL	9				5,220
TOTAL				35	0	9	0	16,989

UL Upland

LL Lowland

TABLE 3-5

BUDGET COMPARISON OF FARMERS AND NEW TECHNOLOGY FARMER 3, ILOILO. (/ha)

		L.Prep. start week	L.Prep. hrs	Cash P	GR P
Farmer's Technology					
Lowland (LL)					
First crop					
F-1 Kapopoy	DS	16	145	0	1,177
F-2 Kapopoy	WS	18	145	304	1,709
F-3 IR5	TP	18	145	51	1,391
F-4 BE 3	TP	18	145	198	2,602
F-5 BE 3	WS	25	145	206	2,354
F-6 IR30	TP	19	145	213	3,328
F-7 IR30	WS	21	145	328	3,686
Second crop					
F-8 IR30	WS	32	145	343	3,630
F-9 IR30	TP	31	145	283	3,630
F-10 BE 3	TP	29	145	422	2,166
F-11 Mung		34	34	0	645
New Technology					
Lowland					
First crop					
N-1 IR36	WS	21	145	463	4,607
N-2 IR36	TP	19	145	479	4,158
N-3 IR28	WS	22	145	463	2,346
N-4 IR28	DS	19	145	394	2,086
N-5 DMR 2		20	145	218	2,600
Second crop					
N-6 IR36	TP	35	145	479	4,538
N-7 IR36	WS	37	145	463	4,538
N-8 Sorghum		36	227	218	1,620

Abbreviations:		
	L.Prep.	Land preparation
	TP	Transplant
	WS	Wet seeded
	DS	Direct seeded

TABLE 3-6

INITIAL MATRIX AND SOLUTION FOR FIRST CROP PERIOD
FARMER 3, ILOILO.

	GR P	Land	Cash P	L.Prep. hrs	Land Preparation (week)							
					17	18	19	20	21	22	23	24
INITIAL MATRIX												
Activity												
F-1 LL	235	1[a]	0	29								
F-3 LL	268	1	10	29								
F-6 LL	623	1	43	29								
F-7 LL	692	1	66	29								
N-1 LL	829	1	93	29								
Resources available		12	800		48	48	48	48	48	48	48	48
SOLUTION												
F-3 LL	536	2	20		10	48						
N-1 LL	4,974	6	558				48	48	48	30		
F-6 LL	1,869	3	129							18	48	21
F-7 LL	692	1	66									29
Resources	8,071	12	773		10	48	48	48	48	48	48	50

[a] $2000 m^2$

TABLE 3-7

INITIAL MATRIX AND SOLUTION FOR SECOND CROP PERIOD FARMER 3, ILOILO.

	GR P	Land	Cash P	L.Prep. hrs	Land Preparation (week)						
					34	35	36	37	38	39	40
INITIAL MATRIX											
Activity											
F-8 LL	659	1[a]	69	29							
F-11 LL	129	1	0	7							
N-7 LL	815	1	93	29							
N-8 LL	280	1	44	45							
Resources available		12	800		48	48	48	48	48	48	48
SOLUTION											
N-7 LL	815	1	93								29
F-8 LL	6,590	10	690		48	48	48	48	48	48	2
F-11 LL	129	1	0								7
Resources	7,534	12	783		48	48	48	48	48	48	38

[a] 2000m^2

TABLE 3-8

INFORMAL CROPPING PATTERN SOLUTION
FARMER 3, ILOILO

		Crop		Land in New Technology	Land in Farmer's Technology	Rice Land DS or WS	Rice Land TP	GR
First Crop Period								
	F-3	Rice	LL		2		2	536
	N-1	Rice	LL	6		6		4,974
	F-6	Rice	LL		3		3	1,869
	F-7	Rice	LL	1[a]		1		692
Second Crop Period								
	N-7	Rice	LL	1		1		815
	F-8	Rice	LL	10[a]		10		6,590
	F-11	Mung	LL		1			129
TOTAL				18	6	18	5	15,605

[a] Although classified in the original data as farmer's technology, wet seeding is new technology.

UL Upland

LL Lowland

TABLE 3-9

BUDGET COMPARISON OF FARMERS AND NEW TECHNOLOGY FARMER 4, ILOILO. (/ha)

		L.Prep. start week	L.Prep. hrs	Cash P	GR P
Farmer's Technology					
Lowland (LL)					
First crop					
F-1 Corn		14	82	76	950
F-2 IR26	TP	19	136	515	2,976
F-3 IR32	TP	18	136	621	3,918
F-4 IR1561	WS	17	68	289	3,210
F-5 IR30	TP	18	136	600	4,134
Second crop					
F-6 BE 3	TP	32	114	102	1,883
F-7 IR1561	WS	36	85	221	2,282
F-8 IR1561	TP	30	130	299	2,451
F-9 IR23	TP	32	130	584	5,549
F-10 IR32	WS	37	41	653	3,063
F-11 Mung		41	77	0	1,290
New Technology					
Lowland					
First crop					
N-1 IR32	TP	19	60	422	4,596
N-2 IR36	WS	19	60	330	4,214
N-3 IR36	DS	19	60	487	4,014
Second crop					
N-4 Mung		38	103	115	3,000
N-5 IR36	TP	34	60	554	4,214
N-6 IR36	WS	37	60	282	3,341

Abbreviations:		
	L.Prep.	Land preparation
	TP	Transplant
	WS	Wet seeded
	DS	Direct seeded

TABLE 3-10

INITIAL MATRIX AND SOLUTION FOR FIRST CROP PERIOD FARMER 4, ILOILO.

		GR P	Land	Cash P	L.Prep. hrs	Land Preparation (week)					
						16	17	18	19	20	21
INITIAL MATRIX											
Activity											
F-1	LL	175	1[a]	15	16						
F-4	LL	584	1	58	14						
F-5	LL	707	1	120	27						
N-1	LL	835	1	84	12						
N-2	LL	777	1	66	12						
Resources available			18	800		48	48	48	48	48	48
SOLUTION											
N-2	LL	7,770	10	660					48	48	24
F-1	LL	1,400	8	120		48	48				
Resources		9,170	18	780		48	48	0	48	48	24

[a] $2000 m^2$

TABLE 3-11

INITIAL MATRIX AND SOLUTION FOR SECOND CROP PERIOD FARMER 4, ILOILO.

	GR P	Land	Cash P	L.Prep. hrs	Land Preparation (week)				
					37	38	39	40	41
INITIAL MATRIX									
Activity									
F-7 LL	412	1[a]	44	17					
F-10 LL	482	1	131	8					
F-11 LL	258	1	0	15					
N-4 LL	577	1	29	21					
N-6 LL	612	1	56	12					
Resources available		18	800		48	48	48	48	48
SOLUTION									
N-6 LL	8,568	14	784		48	48	48	24	
F-11 LL	1,032	4	0					24	36
Resources	9,600	18	784		48	48	48	48	36

[a] $2000 m^2$

TABLE 3-12

INFORMAL CROPPING PATTERN SOLUTION
FARMER 4, ILOILO.

				Land in		Rice Land		
		Crop		New Technology	Farmer's Technology	DS or WS	TP	GR
First Crop Period								
	N-2	Rice	LL	10		10		7,770
	F-1	Corn	LL		8			1,400
Second Crop Period								
	N-6	Rice	LL	14		14		8,568
	F-11	Mung	LL		4			1,032
TOTAL				24	12	24	0	18,770

LL Lowland

TABLE 3-13

BUDGET COMPARISON OF FARMERS AND NEW TECHNOLOGY FARMER 5, ILOILO. (/ha)

		L.Prep. start week	L.Prep. hrs	Cash P	GR P
Farmer's Technology					
Lowland (LL)					
First crop					
F-1 IR1561	WS	20	122	102	1,954
F-2 Kapopoy	DS	17	95	102	1,932
Second crop					
F-3 Mung		48	0	0	940
F-4 BE 3	TP	30	251	115	1,070
Upland (UL)					
First crop					
F-5 Glutinous rice	TP	24	251	98	1,284
F-6 BE 3	TP	20	251	108	1,712
Second crop					
F-7 Corn		44	97	0	57
F-8 Cowpea		45	46	0	875
F-9 Mung		45	95	51	1,250
F-10 BE 3	TP	35	251	115	1,070
New Technology					
Lowland					
First crop					
N-1 IR36	DS	17	95	394	3,655
N-2 IR36	TP	21	196	554	3,655
Second crop					
N-3 IR36	TP	32	196	554	2,741
N-4 Mung		38	95	139	2,000
N-5 Cowpea		37	0	55	1,090
Upland					
First crop					
N-6 IR36	WS	19	97	463	2,631
N-7 IR36	TP	19	196	463	2,924
N-8 IR28	TP	19	196	463	2,924
Second crop					
N-9 Cowpea		44	0	55	1,090
N-10 Mung		44	0	144	1,500

Abbreviations: L.Prep. Land preparation WS Wet seeded
TP Transplant DS Direct seeded

TABLE 3-14

INITIAL MATRIX AND SOLUTION FOR FIRST CROP PERIOD FARMER 5, ILOILO.

		GR P	Land	Cash P	L.Prep. hrs	Land Preparation (week)							
						17	18	19	20	21	22	23	24
INITIAL MATRIX													
Activity													
F-2	LL	386	1[a]	20	19								
N-1	LL	652	$\frac{1}{2}$	79	19								
F-6	UL	321	1	22	50								
N-6	UL	434	1	93	19								
N-7	UL	492	1	93	39								
Resources available			15	900		96	96	96	96	96	96	96	96
SOLUTION													
N-1	LL	1,304	2	158		38							
N-7	UL	2,460	5	465		58	20						
F-6	UL	3,210	10	220			76	96	96	96	96	96	40
Resources		6,974		843		96	96	96	96	96	96	96	40

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[a] $2000m^2$

TABLE 3-15

INITIAL MATRIX AND SOLUTION FOR SECOND CROP PERIOD FARMER 5, ILOILO

	GR	Land	Cash	L.Prep.	Land Preparation (week)			
	P		P	hrs	37	38	39	40
INITIAL MATRIX								
Activity								
F-3 LL	188	1[a]	0	0				
N-5 LL	207	1	11	0				
N-4 LL	372	$\frac{1}{2}$	28	19				
F-8 UL	175	1	0	9				
F-9 UL	240	1	10	19				
N-10 UL	271	1	29	0				
Resources available		15	900		96	96	96	96
SOLUTION								
N-4 LL	744	2	56		38			
N-10 UL	4,065	15	435					
Resources	4,809	17	491		38			

[a] $2000m^2$

TABLE 3-16

INFORMAL CROPPING PATTERN SOLUTION
FARMER 5, ILOILO.

				Land in		Rice Land		
		Crop		New Techno- logy	Farmer's Techno- logy	DS or WS	TP	GR
First Crop Period								
	N-1	Rice	LL	2		2		1,304
	N-7	Rice	UL	5			5	2,460
	F-6	Rice	UL		10		10	3,210
Second Crop Period								
	N-4	Mung	LL	2				744
	N-10	Mung	UL	15				4,065
TOTAL				24	10	2	15	11,783

UL Upland

LL Lowland

TABLE 3-17

BUDGET COMPARISON OF FARMERS AND NEW TECHNOLOGY FARMER 1, PANGASINAN. (/ha)

		L.Prep. start week	L.Prep. hrs	Cash P	GR P
Farmer's Technology					
Upland (UL)					
First crop					
F-1 Tomato		18	138	95	1,951
F-2 Cowpea		18	95	0	645
F-3 Corn/Green		14	88	223	1,173
Second crop					
F-4 Eggplant + tomato		32	104	126	3,628
F-5 Tomato		35	97	238	4,744
Lowland (LL)					
First crop					
F-6 C12	TP	20	162	204	1,598
F-7 Glutinous	TP	20	162	231	1,948
Second crop					
F-8 Tobacco		45	255	344	3,646
F-9 Tomato		40	234	118	4,291
F-10 Cowpea		48	88	55	3,847
Irrigated (partially) (IR)					
First crop					
F-12 BE 3	TP	25	199	240	2,109
F-13 C4	TP	25	136	0	1,976
F-14 LOCAL	TP	20	162	0	2,813
Second crop					
F-15 Mung		47	0	0	3,035
New Technology					
Lowland					
First crop					
N-1 IR561	TP	22	162	175	2,461
N-2 IR36	DS	15	300	208	2,675
Second crop					
N-3 Tomato		39	268	74	1,466

Continued...

TABLE 3-17, Cont'd.

BUDGET COMPARISON OF FARMERS AND NEW TECHNOLOGY FARMER 1, PANGASINAN. (/ha)

			L.Prep. start week	L.Prep. hrs	Cash P	GR P
New Technology						
Irrigated (partially)						
First crop						
N-4	IR36	DS	15	300	208	3,210
N-5	IR36	TP	23	197	376	2,996
N-6	IR28	TP	22	135	376	2,996
Second crop						
N-7	IR36	TP	44	197	250	2,461
N-8	IR28	TP	40	197	250	2,140
N-9	Mung		47	89	89	2,500

Abbreviations:		
	L.Prep.	Land preparation
	TP	Transplant
	WS	Wet seeded
	DS	Direct seeded

TABLE 3-18

INITIAL MATRIX AND SOLUTION FOR FIRST CROP PERIOD FARMER 1, PANGASINAN.

		GR	Land	Cash	L.Prep.	Land Preparation (week)									
		P		P	hrs	15	16	17	18	19	20	21	22	23	24
INITIAL MATRIX															
Activity															
F-1	UL	371	1[a]	19	28										
F-2	UL	129	$\frac{1}{3}$	0	19										
F-7	LL	343	1	46	32										
N-1	LL	457	1	35	32										
N-2	LL	493	$\frac{1}{5}$	42	60										
F-14	IR	562	1	0	32										
N-4	IR	600	1	42	60										
N-6	IR	524	1	75	27										
Resources available			5	1,000		48	48	48	48	48	48	48	48	48	48
SOLUTION															
F-2	UL	387	3	0							48	9			
N-2	LL	986	2	84				24	48	48					
N-1	LL	1,371	3	105									6	48	42
N-4	IR	1,200	2	84								39	42		
N-6	IR	1,572	3	225		48	48	24							
Resources		5,516	13	498		48	48	48	48	48	48	48	48	48	42

[a] $2000m^2$

TABLE 3-19

INITIAL MATRIX AND SOLUTION FOR SECOND CROP PERIOD FARMER 1, PANGASINAN.

	GR	Land	Cash	L.Prep.	Land Preparation (week)						
	P		P	hrs	35	36	37	38	39	40	41
INITIAL MATRIX											
Activity											
F-4 UL	700	1[a]	25	21							
F-5 UL	901	$\frac{1}{3}$	48	19							
F-9 LL	834	1	24	47							
F-10 LL	758	$\frac{1}{5}$	11	18							
F-15 IR	607	1	0	0							
N-7 IR	442	1	50	39							
N-9 IR	482	1	18	18							
Resources available		5	1,000		48	48	48	48	48	48	48
SOLUTION											
F-5 UL	2,703	3	144		48	9					
F-9 LL	4,170	5	120			39	48	48	48	48	4
F-15 IR	3,035	5	0								
Resources	9,908	13	264		48	48	48	48	48	48	4

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[a] $2000m^2$

TABLE 3-20

INFORMAL CROPPING PATTERN SOLUTION
FARMER 1, PANGASINAN.

		Crop		Land in New Technology	Land in Farmer's Technology	Rice Land DS or WS	Rice Land TP	GR
First Crop Period								
	F-2	Cowpea	UL		3			387
	N-2	Rice	LL	2		2		986
	N-1	Rice	LL	3			3	1,371
	N-4	Rice	IR	2		2		1,200
	N-6	Rice	IR	3			3	1,572
Second Crop Period								
	F-5	Tomato	UL		3			2,703
	F-9	Tomato	LL		5			4,170
	F-15	Mung	IR		5			3,035
TOTAL				10	16	4	6	15,424

UL Upland

LL Lowland

IR Irrigated

TABLE 3-21

BUDGET COMPARISON OF FARMERS AND NEW TECHNOLOGY FARMER 2, PANGASINAN. (/ha)

		L.Prep. start week	L.Prep. hrs	Cash P	GR P
Farmer's Technology					
Upland (UL)					
First crop					
F-1 C4	TP	25	100	195	3,466
F-2 Corn		13	130	0	1,560
Second crop					
F-3 Cowpea		46	102	31	169
F-4 Cotton		37	182	682	1,086
Lowland (LL)					
First crop					
F-5 Wagwag	TP	20	130	311	2,803
F-6 IR561	TP	20	130	256	3,667
F-7 IR26	TP	20	130	197	2,756
Second crop					
F-8 Cotton		44	142	470	3,584
F-9 Mung		46	71	20	1,500
F-10 IR28	TP	36	130	170	1,083
F-11 Cowpea		48	123	0	290
New Technology					
Upland					
First crop					
N-1 IR36	DS	17	300	0	1,305
N-2 IR36	DS	17	300	84	2,782
N-3 IR36	DS	17	300	594	2,675
N-4 IR36	DS	17	300	844	2,675
Second crop					
N-5 Cotton		44	182	284	1,925
Lowland					
First crop					
N-6 IR42	TP	25	100	168	5,350
N-7 IR42	TP	25	100	84	2,675
N-8 IR42	TP	25	100	0	1,391
N-9 IR36	TP	24	100	0	963
N-10 IR36	TP	24	100	84	1,284
N-11 IR36	TP	24	100	168	2,782
N-12 IR36	TP	24	100	252	3,210
N-13 IR36	DS	15	200	486	4,280

Continued...

TABLE 3-21, Cont'd.

BUDGET COMPARISON OF FRAMERS AND NEW TECHNOLOGY FARMER 2, PANGASINAN. (/ha)

		L.Prep. start week	L.Prep. hrs	Cash P	GR P
New Technology, cont'd.					
Lowland, cont'd.					
Second crop					
N-14 IR36	TP	37	100	561	1,498
N-15 Mung		46	71	18	2,000

Abbreviations:		
	L.Prep.	Land preparation
	TP	Transplant
	WS	Wet seeded
	DS	Direct seeded

TABLE 3-22

INITIAL MATRIX AND SOLUTION FOR FIRST CROP PERIOD FARMER 2, PANGASINAN.

		GR P	Land	Cash P	L.Prep. hrs	Land Preparation (week)						
						15	16	17	18	19	20	21
INITIAL MATRIX												
Activity												
F-1	UL	654	1[a]	39	20							
F-2	UL	312	1	0	26							
N-2	UL	540	$\frac{1}{2}$	17	60							
F-6	LL	682	1	51	26							
F-7	LL	512	1	39	26							
N-6	LL	1,037	1	35	20							
N-13	LL	759	1	97	40							
Resources available			6	600		48	48	48	48	48	48	48
SOLUTION												
F-2	UL	312	1	0		26						
N-2	UL	540	1	17							26	38
N-13	UL	4,554	6	582		22	48	48	48	48	22	
Resources		5,406		599		48	48	48	48	48	48	38

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[a] $2000m^2$

TABLE 3-23

INITIAL MATRIX AND SOLUTION FOR SECOND CROP PERIOD FARMER 2, PANGASINAN.

	GR	Land	Cash	L.Prep.	Land Preparation (week)				
	P		P	hrs	44	45	46	47	48
INITIAL MATRIX									
Activity									
F-3 UL	28	1[a]	6	20					
N-5 UL	328	$\frac{1}{2}$	57	36					
F-8 LL	623	1	94	28					
F-9 LL	296	1	4	14					
N-15 LL	396	1	4	14					
Resources available		6	600		48	48	48	48	48
SOLUTION									
N-5 UL	656	2	114		48	24			
F-8 LL	3,115	5	470			24	48	48	20
N-15 LL	396	1	4						14
Resources	4,167	8	588		48	48	48	48	34

[a] 2000m^2

TABLE 3-24

INFORMAL CROPPING PATTERN SOLUTION FARMER 2, PANGASINAN.

			Land in		Rice Land		
	Crop		New Technology	Farmer's Technology	DS or WS	TP	GR
First Crop Period							
F-2	Corn	UL		1			312
N-2	Rice	UL	1		1		540
N-13	Rice	LL	6		6		4,554
Second Crop Period							
N-5	Cotton	UL	2				656
F-8	Mung	LL		5			3,115
N-15	Mung	LL	1				396
TOTAL			10	6	7	0	9,573

UL Upland

LL Lowland

TABLE 3-25

BUDGET COMPARISON OF FARMERS AND NEW TECHNOLOGY FARMER 3, PANGASINAN. (/ha)

		L.Prep. start week	L.Prep. hrs	Cash P	GR P
Farmer's Technology					
Upland (UL)					
First crop					
F-1 Peanut		19	112	168	2,400
F-2 Managasa	DS	20	146	369	1,711
Second crop					
F-3 Mung		36	36	17	2,015
F-4 Cowpea		38	140	5	1,858
F-5 Peanut		33	107	168	2,418
Lowland (LL)					
First crop					
F-6 C4	TP	25	131	283	2,085
Second crop					
F-7 Mung		48	126	23	935
New Technology					
Upland					
First crop					
N-1 Peanut + corn		19	120	788	4,050
N-2 Corn		20	60	184	1,560
N-3 Peanut		19	120	664	3,320
N-4 IR36	DS	18	138	234	2,140
Second crop					
N-5 Cowpea		37	80	657	3,150
N-6 Peanut		31	120	664	3,320
N-7 Mung		34	40	27	700
N-8 Green Corn		38	60	184	1,300
Lowland					
First crop					
N-9 IR36	DS	15-34	245	731	4,280
N-10 Green corn		19	120	425	2,600
Second crop					
N-11 IR36	TP	36	239	559	1,177
N-12 IR36	TP	34	239	559	3,745
N-13 Mung		51	0	668	2,500

Abbreviations:				
	L.Prep.	Land preparation	WS	Wet seeded
	TP	Transplant	DS	Direct seeded

TABLE 3-26

INITIAL MATRIX AND SOLUTION FOR FIRST CROP PERIOD FARMER 3, PANGASINAN.

	GR P	Land	Cash P	L.Prep. hrs	Land Preparation (week)								
					15	16	17	18	19	20	21	22	23
INITIAL MATRIX													
Activity													
F-1 UL	446	1[a]	34	22									
N-1 UL	652	1	158	24									
N-3 UL	531	$\frac{1}{6}$	133	24									
F-6 LL	360	1	57	26									
N-9 LL	710	1	146	48									
N-10 LL	435	1	85	24									
Resources available		6	2,000		48	48	48	48	48	48	48	48	48
SOLUTION													
N-1 UL	3,912	6	948								48	48	48
N-9 LL	4,260	6	876		48	48	48	48	48	48			
Resources	8,176	12	1,824		48	48	48	48	48	48	48	48	48

[a] $2000 m^2$

TABLE 3-27

INITIAL MATRIX AND SOLUTION FOR SECOND CROP PERIOD FARMER 3, PANGASINAN.

		GR	Land	Cash	L.Prep.	Land Preparation (week)			
		P		P	hrs	33	34	35	36
INITIAL MATRIX									
Activity									
F-3	UL	400	1[a]	3	7				
F-5	UL	450	1	34	21				
N-5	UL	499	1	131	16				
N-6	UL	531	1	133	24				
N-7	UL	135	1	5	8				
			6						
F-7	LL	182	1	5	25				
N-12	LL	637	1	112	48				
N-13	LL	366	1	134	0				
Resources available			6	2,000		48	48	48	48
SOLUTION									
N-5	UL	2,994	6	786				48	48
N-12	LL	1,274	2	224		48	48		
N-13	LL	1,464	4	536					
Resources		5,732	12	1,546		48	48	48	48

[a] $2000m^2$

TABLE 3-28

INFORMAL CROPPING PATTERN SOLUTION
FARMER 3, PANGASINAN.

		Crop		Land in		Rice Land		GR
				New Technology	Farmer's Technology	DS or WS	TP	
First Crop Period								
	N-1	Peanut + Corn	UL	6				3,912
	N-9	Rice	LL	6		6		4,260
Second Crop Period								
	N-5	Cowpea	UL	6				2,994
	N-12	Rice	LL	2			2	1,274
	N-13	Mung	LL	4				1,464
TOTAL				24	0	6	2	13,908

UL Upland

LL Lowland

TABLE 3-29

BUDGET COMPARISON OF FARMERS AND NEW TECHNOLOGY FARMER 5, PANGASINAN. (/ha)

		L.Prep. start week	L.Prep. hrs	Cash P	GR P
Farmer's Technology					
Upland (UL)					
First crop					
F-1 Wagwag	TP	19	130	247	1,182
F-2 Peanut		18	100	240	1,650
Second crop					
F-3 Cotton		30	205	333	4,685
F-4 Mung		47	49	10	1,770
Lowland (LL)					
First crop					
F-5 IR36	TP	22	100	206	3,638
Second crop					
F-6 IR36	TP	37	100	250	1,391
New Technology					
Upland					
First crop					
N-1 IR36	TP	22	200	252	3,638
N-2 IR36	DS	15	200	252	2,675
Second crop					
N-3 Mung		46	66	45	1,000

Abbreviations:		
	L.Prep.	Land preparation
	TP	Transplant
	WS	Wet seeded
	DS	Direct seeded

TABLE 3-30

INITIAL MATRIX AND SOLUTION FOR FIRST CROP PERIOD FARMER 5, PANGASINAN.

		GR	Land	Cash	L.Prep.	Land Preparation (week)								
		P		P	hrs	15	16	17	18	19	20	21	22	23
INITIAL MATRIX														
Activity														
F-1	UL	313	1[a]	49	26									
N-2	UL	485	1	50	40									
N-1	UL	677	$\frac{1}{3}$	50	40									
F-5	LL	686	1	41	20									
Resources available			14	1,000		48	48	48	48	48	48	48	48	48
SOLUTION														
N-2	UL	1,455	3	150		48	48	24						
F-5	LL	9,604	14	574				24	48	48	48	48	48	16
Resources		11,059	17	724		48	48	48	48	48	48	48	48	16

[a] $2000m^2$

TABLE 3-31

INITIAL MATRIX AND SOLUTION FOR SECOND CROP PERIOD FARMER 5, PANGASINAN.

	GR P	Land	Cash P	L.Prep. hrs	Land Preparation (week)						
					37	38	39	40	41	42	43
INITIAL MATRIX											
Activity											
F-4 UL	352	1[a]	2	10							
N-3 UL	191	$\frac{1}{3}$	9	13							
F-6 LL	228	1	50	20							
Resources available		14	1,000		48	48	48	48	48	48	48
SOLUTION											
F-4 UL	1,056	3	6							8	22
F-6 LL	3,192	14	700		48	48	48	48	48	40	
Resources	4,248	17	706		48	48	48	48	48	48	22

[a] $2000 m^2$

TABLE 3-32

INFORMAL CROPPING PATTERN SOLUTION
FARMER 5, PANGASINAN.

		Crop		Land in		Rice Land		GR
				New Technology	Farmer's Technology	DS or WS	TP	
First Crop Period								
	N-2	Rice	UL	3		3		1,455
	F-5	Rice	LL		14		14	9,604
Second Crop Period								
	F-4	Mung	UL		3			1,056
	F-6	Rice	LL		14		14	3,192
TOTAL				3	31	3	28	15,307

UL Upland

LL Lowland